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ECOLOGY OF THE ARCTIC FOX

IN NORTHERN AND WESTERN ALASKA

A

THESIS

Presented to the Faculty of the

University of Alaska in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE

By

David Lee Chesemore, B. S.

College, Alaska

May, 1967

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ECOLOGY OF THE ARCTIC FOX

IN NORTHERN AND WESTERN ALASKA

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ABSTRACT

The economic importance of the white fox in Barrow Village and its ecology on the Teshekpuk Lake Section of the Arctic Coastal Plain, Alaska, were studied from July, 1961, through May, 1963, and from September, 1966, through January, 1967.

White fox pelts are economically prime from December to April with the best pelts being taken in January and February. In Alaska high fox populations occur on an average of every 3.6 years with corresponding lows every 3.9 years. Alaska's fox cycle is equal in duration but not in phase with that of other northern areas. Peak fox populations are naturally associated with lemming highs since they are the primary fox food throughout the year with sea mammals and caribou also important throughout the year. Birds and their eggs form a large part of the fox diet in summer.

Depth to permafrost and soil texture govern fox den location in ice-core mounds with a minimum mound height of 1 m necessary for a successful den. Grasses dominate den vegetation, replacing typical dry tundra plants common in other areas.

Since 1929 a steady decline of white fox pelt value and total harvest has occurred throughout Alaska. Although the potential for a large harvest still exists in the region studied, today fox trapping has little impact on Barrow's economy.

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ACKNOWLEDGMENTS

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Many persons have helped me develop this study from its initial planning stages to final thesis form: For this help, I would like to sincerely thank Mr. Robert F. Scott, who first proposed the white fox study; Dr. James S. Lindzey, for his evaluation and guidance during the early phases of the work; Dr. David R. Klein, for his valuable suggestions and patient, critical review of the final draft of the thesis; Dr. Frederick C. Dean, Dr. James E. Morrow, and Dr. L. Gerard Swartz, for their reviews and comments on various sections of the thesis; Dr. Vernon L. Harms and Dr. Leslie A. Viereck, for their identifications of vascular plants and lichens; Dr. Francis H. Fay and Dr. Robert L. Rausch, Arctic Health Research Center, Anchorage, for their help with fox autopsy techniques and parasite identification; and Dr. Torcom Chorbajian, for his aid in statistical analysis of material in the den ecology section.

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Special thanks are due to: Mr. Max Brewer and his competent A. R. L. staff, particularly Pete Sovalik, Chester Lampe, Jimmy Ningeak, Bill Brower, and Charlie Edwardson for their support during field work; the late Dr. Otto W. Geist, for sharing his knowledge of Alaska's north and its people with a beginning biologist; Nate and Sadie Nayokok, Tom Brower, and Al Hopson, for their warm hospitality and sharing with me their considerable knowledge of Barrow Village and life on the arctic coast; Mr. Dwain Davies, for his help during the summer field work and the initial analysis of data; Mr. John Trent, for his "bug-room" operations in preparation of fox skeletal materials; Mr. Grant Lortie, for his drafting skills; and Mrs. Mary Krogstie, for her interest and care in typing the final copy of this thesis.

Special recognition is given to my wife, Jan, for her patience, good-humor, and unfailing support during all phases of the study. Without her aid, this thesis could never have been written.

Scientific nomenclature follows that of Anderson (1959), Hall and Kelson (1959), and the American Ornithologists' Union (1957).

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INTRODUCTION

The white color-phase of the arctic fox (*Alopex lagopus innuitus* Merriam), commonly known as the white fox, is the primary, and often only source of earned monetary income to many of the Alaskan Eskimos living in northern and western Alaska. Although modern civilization continues to reduce this dependence of Alaskan natives on existing wildlife resources; fish, game, and furbearers still play a major economic role in their lives today.

In the past, little research has been done on the white fox of northern and western Alaska. Scattered reports are numerous but almost all deal only superficially with its biology and management in Alaska. This lack of basic information needed for sound management prompted the initiation of this study which was begun in an attempt to fulfill two basic research objectives:

1. To determine the life history, distribution, and abundance of white fox in north coastal Alaska.
2. To examine factors affecting availability and value of this fur animal to local trappers.

This report represents the findings of the field and laboratory work from September, 1961, through May, 1963, and from September, 1966, through January, 1967. Field work on the white fox was confined

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to the Teshekpuk Lake Section of the Arctic Coastal Plain of northern Alaska (Fig. 1). Summer field work was conducted at Camps I and IV, Tusikvoak Lake (71°3'16" N, 156°22'33" W), Camp II, Half-Moon-Three (70°46'36" N, 155°37'40" W), and Camp III, at the eastern end of Teshekpuk Lake (70°33'29" N, 152°37'40" W). Tracked vehicles, aircraft, a canvas fold-boat, and walking supplied the necessary transportation to and around these areas. Winter work was conducted primarily near Barrow Village during November, December, and March. Aircraft flights and a cross-country trip inland with Eskimo trappers to the area south of Teshekpuk Lake provided additional data on fox biology.

Between September, 1961, and March, 1963, 130 days were spent in the field gathering data. One or two assistants aided data collection during the summer while winter work was usually conducted alone or with local Eskimo trappers.

The economic and social conditions at Barrow Village which are described are representative of the period September, 1961, through March, 1963.

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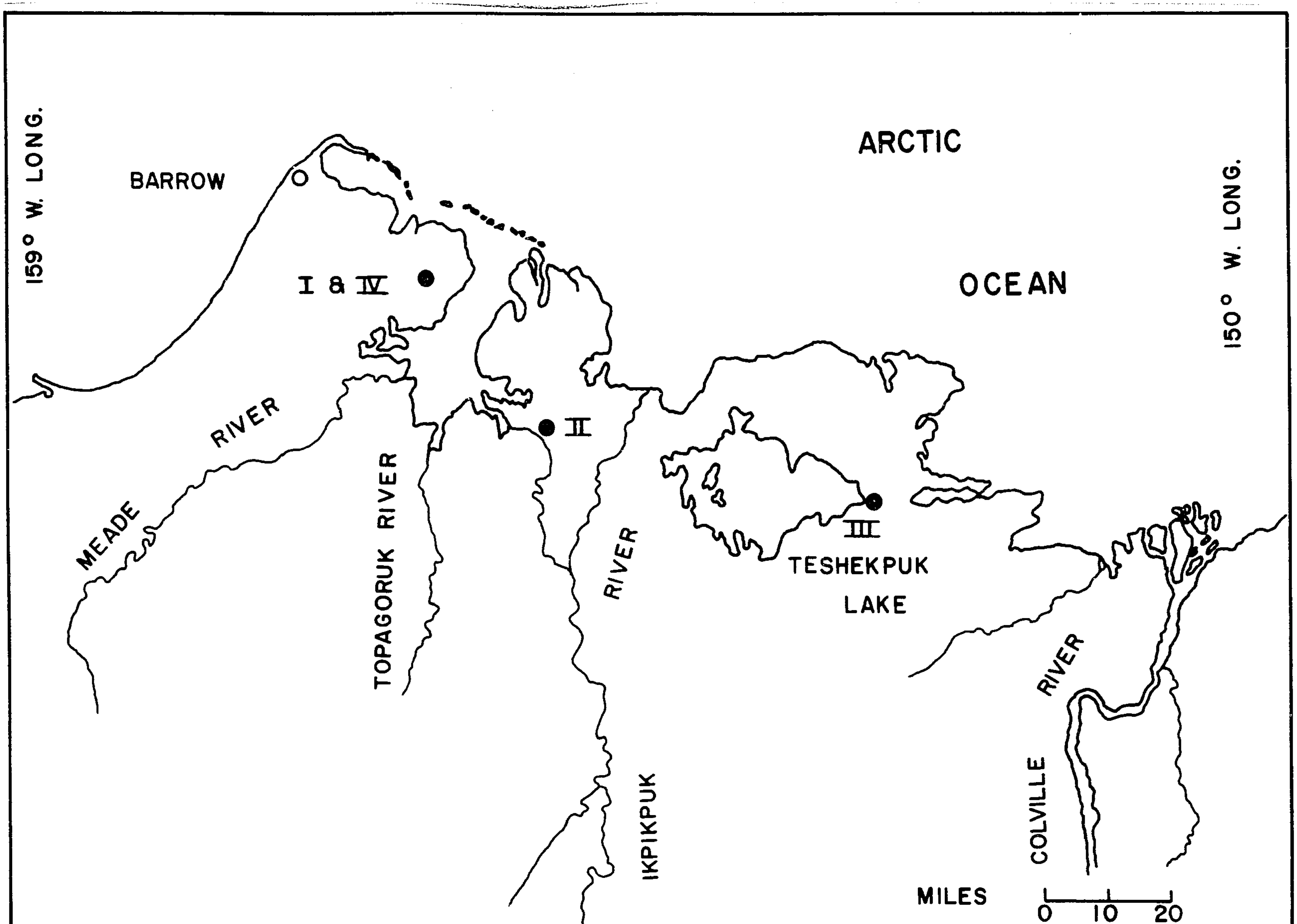
Fig. 1. Location of study areas on the Teshekpuk Lake Section of the Alaskan Arctic Slope.



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FOSSIL RECORD

Arctic fox remains have been found in European Pleistocene deposits, being especially common in deposits containing abundant reindeer and lemming remains (Trovessart 1899; Zittel 1925). Beddard (1902) states that the remains of arctic fox have been found as far south as Germany and England.

Lavrov (1932) sums up the geologic history of this group in the following statement:

> In early times, . . . the distribution range of the arctic fox covered a much greater area than it does at present. In excavations and examinations of caves, bones have been discovered belonging to the prehistoric arctic fox (in France, Switzerland, former Austria-Hungary, Germany, Poland, etc.). Bones have also been found in Siberia, near Krasnoyarsk, Nizhne-Udinsk, and other places. These remains show that. . . the arctic fox inhabited the whole of Europe and apparently a large part of the territory of Siberia.

Arctic fox have a probable Old World or Nearctic origin in the Pleistocene, but a definite fossil record is lacking (Savage 1958).

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CLASSIFICATION

The family Canidae is composed of the wolves, dogs, foxes, and jackals and their relatives. Huxley (1880) divides the Canidae into two main groups: the wolf-like forms, "Thooids", and the fox-like forms, "Alopecoids", basing his classification on differences in skull structure. Beddard (1902) discusses in detail the various characters used by Huxley in separating the Canidae. Simpson (1945) divides the Canidae into two subfamilies, placing the arctic fox, *Alopex*, into the subfamily Caninae, with the red and kit fox, *Vulpes*, the fennec fox, *Fennecus*, and the grey fox, *Urocyon*. Miller (1912) and Lavrov (1932) give detailed descriptions of the anatomical differences between *Alopex* and other members of the Caninae.

Taxonomists divide the arctic fox group into four different species (Miller 1924; Anderson 1946), two species (Ognev 1962), or include all forms in one circumpolar species (Braestrup 1941). Based on the latter grouping, three subspecies of arctic fox occur in Alaska: *Alopex lagopus innuitus*, *A. l. hallensis*, and *A. l. pribilofensis* (Hall and Kelson 1959). Only *A. l. innuitus*, the continental arctic or white fox, has been studied in detail here. A blue color phase of this species predominates in some northern areas, but this study deals primarily with the white phase of the arctic fox.

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DISTRIBUTION

In North America, the white fox occurs on the arctic coast and tundra in western and northern Alaska, northern Yukon, Mackenzie, and Keewatin districts of the Northwest Territories to the west side of Hudson Bay and Baffin Island; the northern parts of Alberta, Saskatchewan, and Manitoba, and that part of northwestern Ontario bordering on Hudson Bay; and is also found on most of the islands of the Canadian Arctic and ranges far out on the sea ice in winter (Anderson 1946).

In Alaska, the white phase of the arctic fox is found along the coast from the Kuskokwim River north to Point Barrow and eastward along the arctic coast to the Canadian border (Dufresne 1946; Petroff 1898). White foxes predominate on St. Lawrence, St. Matthew, Hall and Diomede Islands, as well as most of the other islands in the Bering Sea. They also occur among the predominantly blue color phase of the arctic fox on the Pribilof and Aleutian Islands.

Years ago, traders in the Kotzebue area reported a sizeable catch of white foxes annually from that local area, but now this species is rare near Kotzebue (Scott 1951). Burns (correspondence) reports that they are also uncommon in the interior portion of the Seward Peninsula.

The erratic movements of the white fox between the islands and coasts of both Alaska and Siberia are apparently dependent upon the ice

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conditions existing in those respective regions. This species is capable of, and certainly does at times, travel for long distances over the sea ice. Foxes have been observed far out on the polar pack ice, approximately 640 km north of the arctic coast of northern Alaska (Brewer *viva voce*). Dead foxes were found on the floating ice island Arliss II and others were seen occasionally on the ice island as it drifted deeper into the Arctic ice pack towards the North Pole (Robinson *viva voce*).

During the 1962-63 trapping season, an Eskimo from Wainwright, Alaska, trapped a white fox bearing a Russian neck tag. Assuming the fox was tagged in Russian territory, it had completed a considerable journey before being finally trapped at Wainwright.

A number of records exist of the white fox being taken as far south as the Brooks Range and in the Interior of Alaska (Appendix I), but most of the white fox population is found on the tundra and coastal plain areas of northern and western Alaska (Fig. 2). Habitat preference for arctic tundra conditions, and perhaps interspecific competition with red fox (*Vulpes fulva*) are the most probable reasons for the existing distribution of the white fox in Alaska.

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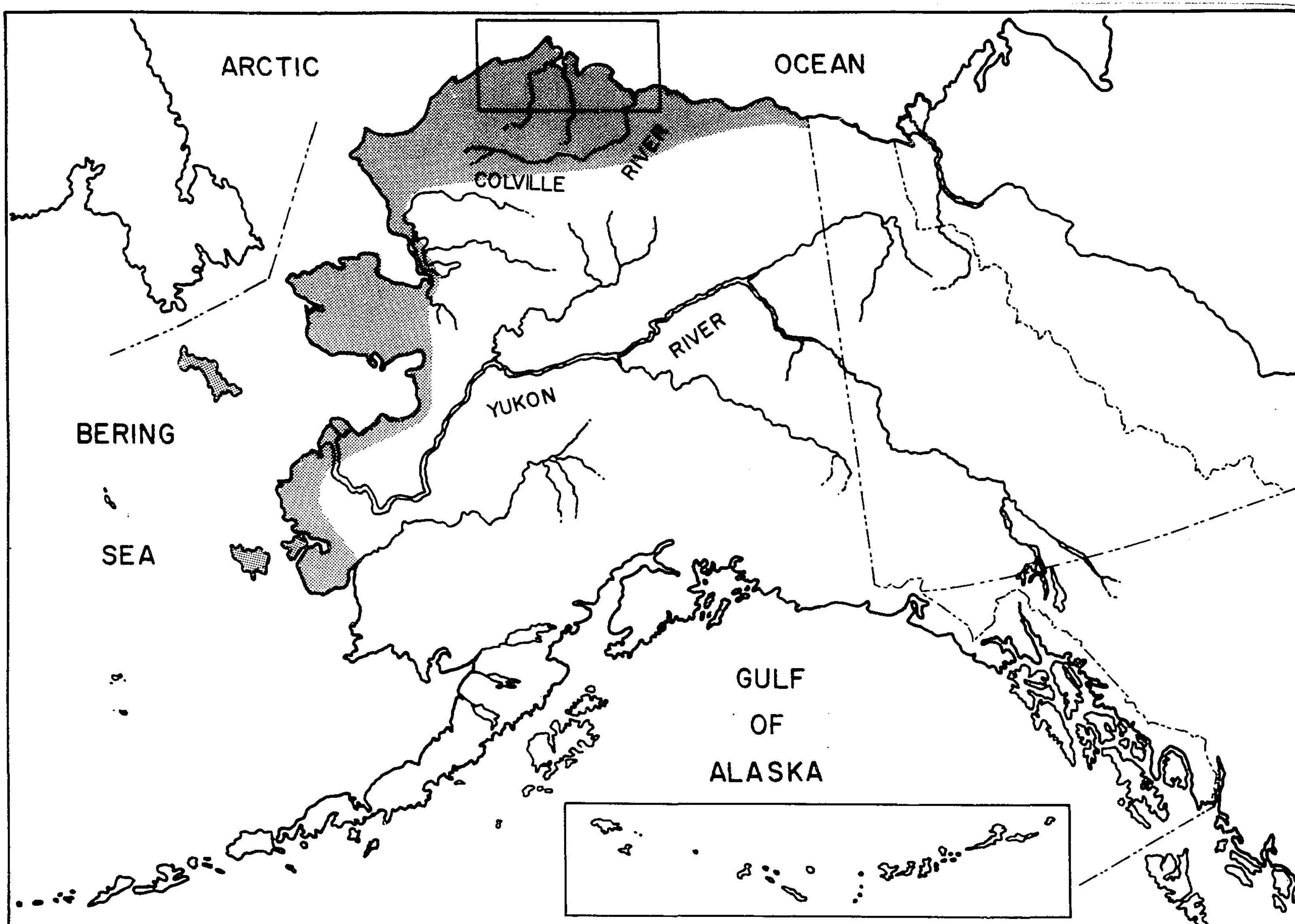
Fig. 2. General distribution of the white fox in Alaska. Rectangle encloses study area shown in Fig. 1.



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DESCRIPTION OF THE STUDY AREA

Physiography

The Arctic Slope can be separated into three major physiographic provinces: the Brooks Range, the Arctic Foothills, and the Arctic Coastal Plain. Payne et al. (1952), Britton (1957), and Gryc (1958) give detailed descriptions of the physical features of the Arctic Foothills and the Brooks Range Provinces of the Alaskan Arctic Slope.

Two divisions of the Arctic Coastal Plain are recognized: the Teshekpuk Lake Section, and the White Hills Section. These sections are separated primarily on the basis of prominent differences in elevation. The White Hills Section consistently exceeds the maximum 300 foot elevations attained by the Teshekpuk Lake Section.

The most striking characteristic of the Teshekpuk Lake Section is the monotonous uniformity of its landscape (Fig. 3). Most of the Arctic Coastal Plain is less than 50 feet above sea level, but it does reach elevations of 200 to 500 feet above sea level along its southern boundary. The lowland plains consist of low, broad ridges of aeolian origin (Gryc 1958). The broad ridges and low valleys usually have a local relief of less than 30 feet near the northern coast of Alaska. Eastward in the White Hills Section the southern boundary of the Arctic Coastal Plain may reach heights of 1,200 feet (Black and Barksdale

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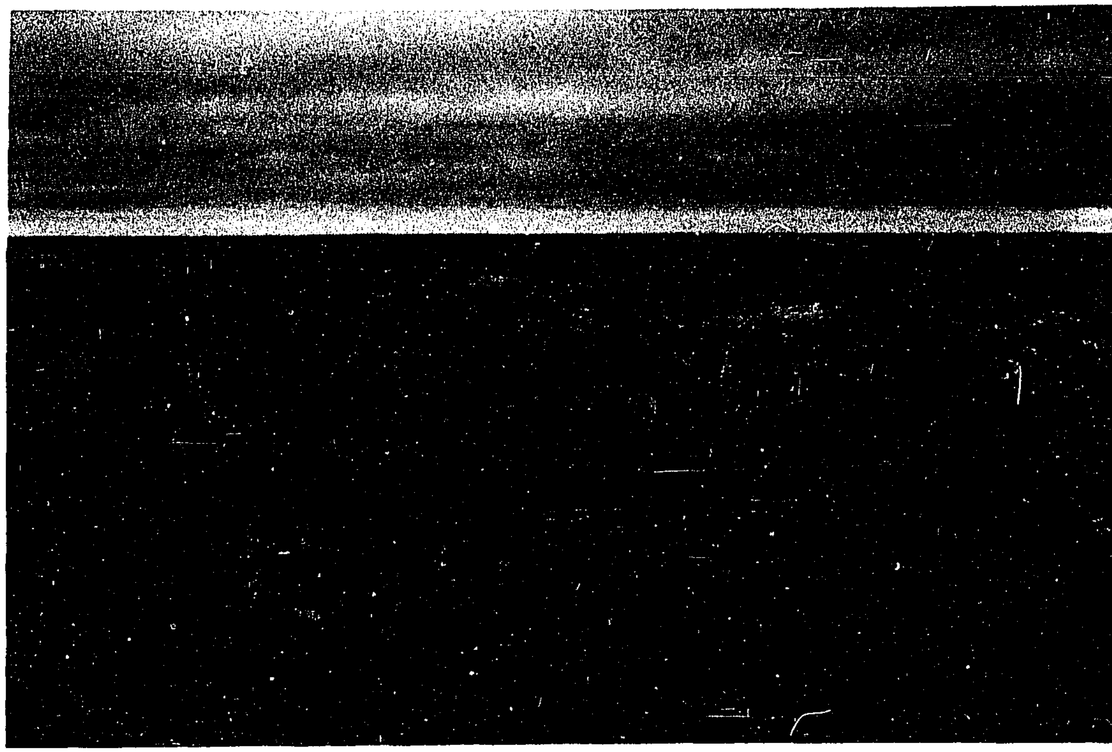

Fig. 3. Characteristic flat plains of the Teshekpuk Lake Section of northern Alaska.

Fig. 4. Preferred den site habitat of the white fox on the Arctic Coastal Plain.

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1949).

Permafrost greatly affects the landscape of the Arctic Coastal Plain and underlies the entire Arctic Slope, reaching a depth of 1,200 feet in the Barrow Village area (Hopkins et al. 1955). Temperatures as low as -10.7°C have been recorded from this depth (Gryc 1958).

Permafrost blocks all internal and surface drainage, producing a myriad of permanent and temporary bodies of water varying in size from very small ponds to large lakes. These lakes occupy 20 to 95% of the total area of the Teshekpuk Lake Section (Britton 1957). Lake shapes vary from rectangular to elliptical forms, and most are very shallow in depth. The deepest spot found in Teshekpuk Lake was only slightly more than 6 m.

The parallel orientation of many of the lakes in the Teshekpuk Lake Section is a rare phenomenon (Black and Barksdale 1949). Prevailing winds parallel to the long axis of these lakes are believed to have produced the oriented lakes common only on the Arctic Coastal Plain.

Most rivers and streams of the Arctic Slope flow northward eventually reaching the Arctic Ocean. Most streams are small, meander extensively, and are sluggish (Spetzman 1951). The Colville River in the western part of the Arctic Coastal Plain intercepts many of the rivers that flow from the south and directs this water across the flat plains in one main channel. The Inaru is the only large river that

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lies completely within the Arctic Coastal Plain.

Many characteristic land features are produced by the permafrost underlying the Arctic Coastal Plain: high- and low-center polygons, and frost boils. Polygonal ground is common throughout the wetter areas of the Teshekpuk Lake Section. Small earth and ice mounds, usually .3 to 1.3 m high, occur over most of the coastal plain (Fig. 4).

Geology and Soils

The flatness of the Arctic Coastal Plain reflects the simplicity of its underlying geologic structure (Gyrc 1958). The Gubik Formation mantles the Arctic Coastal Plain (Britton 1957):

> The Gubik Formation, consisting of Quarternary age, unconsolidated marine and non-marine gravel, sand, silt, clay, and peat, forms a mantle throughout the Plain as much as 150 feet thick over rocks of Upper Cretaceous and Early Tertiary age. Cretaceous rocks of the Colville Group include essentially flat-lying shale, sandstone, bentonite, and tuff. Early Tertiary rocks of the Sagavanirktok Formation including non-marine, poorly consolidated conglomerate, silty sandstone, siltstone, lignite, and cannel coal, occur only in the White Hills Section.

Payne *et al.* (1952) reports that exposures of geologic materials older than the Gubik Formation are not found anywhere on the Arctic Coastal Plain except along the bluffs of major streams and on the seacoast.

Soil materials are composed of the components of the Gubik Formation and more recent deposits of similar geologic materials

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(Britton 1957). Peat deposits are forming in many areas on the Arctic Coastal Plain. Black (1951) found loess and eolian deposits as well as sand dunes scattered throughout many areas of the Plain (Figs. 5 and 6).

The soils of the Arctic Slope are usually acid, very low in nitrogen, and low in phosphorus and potassium (Wiggins and Thomas 1962). The following description of soils in that area is taken primarily from the works of Drew (1957), Tedrow et al. (1958), Britton (1957), and Wiggins and Thomas (1962).

The soils of the Arctic Slope have been classified as Lithosols, Regosols, Arctic Brown, Tundra, and Bog. Only Arctic Brown, Tundra, and Bog soils are common on the Arctic Coastal Plain of northern Alaska.

Intrazonal Tundra and Bog soils cover most of the flat land of the Arctic Coastal Plain. Arctic Brown soil is confined on the Plain to well-drained beach ridges left on land by the emergence of the Arctic Coastal Plain from the sea. Tundra soil mantles all but the wettest and driest terrain of the Arctic Coastal Plain. Physical processes associated with permafrost presence have usually disrupted the morphology of tundra soil so conventional soil horizons have little meaning in its study. Bog soils occupy the wettest terrain on the Arctic Coastal Plain.

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Fig. 5. Sand dunes along the Chipp River near Camp II. _Salix_ sp. stabilizes the sand.

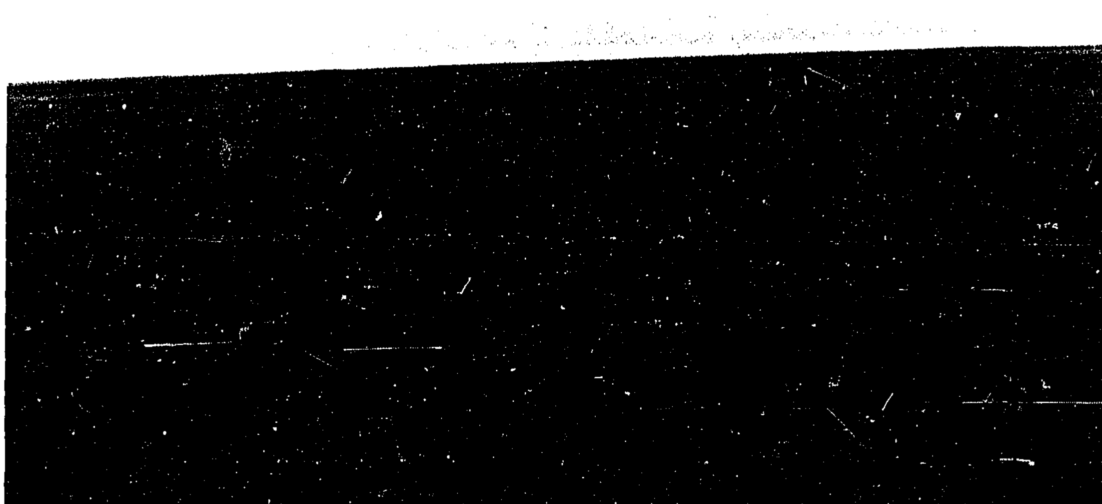

Fig. 6. Low sand mounds used as den sites by white foxes near Camp II.

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Arctic Brown soil is characterized by dark brown coloration in the upper horizon, grading with depth to yellow and the color of the existing parent material. Fine crumb structure predominates in the A horizon and decreases in the B horizon. Single-grain structure predominates in the C horizon. The A horizon is usually strongly acid, highly organic, and exhibits clay accumulation. With depth there is a gradual decrease in organic matter and an increase in pH. Clay accumulation, which persists in the B horizon, gives way to medium and fine sand in the C horizon. Three phases have been described; a shallow phase which may be neutral in reaction in the surface layer, a moderately well-drained phase which is gradational to Tundra soil, and the normal phase.

Tundra soil, predominantly of silt loam texture and highly variable in profile structure, is a gley soil. Large variations in color, amount of organic matter, drainage, depth of thaw, intensity of mottling, and topographic location provide criteria for recognition of two units of Tundra soils. Within each unit there are normal, dry, and wet phases. Upland Tundra soil occurs on the relatively drier slopes and rounded hilltops of the foothills. The upper horizons have less organic matter and greater oxidation than the soils of wetter areas. Meadow tundra soil is more prominent on the Arctic Coastal Plain. It has a greater accumulation of organic matter and coloration tending to a dark grey.

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Bog soils are characteristic of wet areas on the Arctic Coastal Plain. They occupy the wettest terrain and are characterized by saturation of water and are often covered by it. They contain heavy accumulations of organic material. On acid materials these soils have surface organic layers more than 15 cm deep overlying blue-grey mineral layers. Mineral layers underlain by calcareous materials are grey-brown in color as in certain of the Tundra soils. Two units, each with a normal and a dry phase, have been recognized on an arbitrary basis: full bogs, those having a surface thickness of organic matter greater than 30 cm; and half bogs, those having a surface thickness of organic matter between 15 and 30 cm. Half bog soils predominate in the Barrow Village area.

Climate and Weather

The climate of the Alaskan Arctic Slope is severe (Table 1). It is characterized by long, cold winters and short, cool summers. Heavy fogs, cloudiness, high humidity, and brisk winds accompany the summer months. Climatic extremes increase as the Foothills and Brooks Range Provinces are approached.

Temperatures on the Arctic Slope may fall below freezing during any month of the year. A growing season of approximately 90 days is augmented by the extremely long periods of sunlight during the summer months. February is the coldest month of the year, with July and

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Table 1. Temperature and precipitation records at Barrow Village, Alaska, from January, 1920 through December, 1960[1]

Month	Mean temperature (F) Min.	Mean temperature (F) Ave.	Mean temperature (F) Max.	Highest temp. (F)	Lowest temp. (F)	Precipitation (in.) Total	Precipitation (in.) Snowfall
January	-20.2	-15.6	- 8.9	33.0	-53.0	.18	2.4
February	-24.7	-18.4	-12.0	32.0	-56.0	.17	2.2
March	-21.9	-15.1	- 8.1	30.0	-52.0	.11	1.6
April	- 7.5	0.0	7.4	42.0	-42.0	.11	2.3
May	13.2	18.7	24.2	45.0	-18.0	.12	1.5
June	29.0	33.6	38.5	70.0	8.0	.36	.4
July	33.3	39.6	45.7	78.0	22.0	.77	.7
August	33.2	38.3	43.4	73.0	20.0	.90	.6
September	26.8	30.5	34.2	62.0	1.0	.64	3.0
October	11.7	16.7	21.6	43.0	-19.0	.50	6.9
November	- 6.0	- .1	5.8	39.0	-40.0	.23	3.6
December	-17.0	-11.0	- 5.1	34.0	-55.0	.17	2.7
Total						4.26	28.0

[1]Records compiled by U.S. Department of Commerce (1965), Weather Bureau.

August usually being the warmest months. Freeze-up, the period when open water develops a permanent ice cover, may occur at any time from late August to the end of September, with break-up beginning in May. Many large lakes remain ice-covered on the Arctic Coastal Plain until mid-July. Weather records for 40 years, 1920 to 1960, from the Barrow Village weather station indicate that 78 F (25.6 C) and a -56 F (-13.3 C) are the maximum and minimum temperature records for that area. Umiat, near the southern edge of the Arctic Slope in the Foothills Province, has 85 F (29.3 C) and a -63 F (-17.2 C) as maximum and minimum record temperatures respectively (Bliss 1956).

Precipitation is scanty on the Arctic Slope. Were it not for the lack of drainage and low temperatures retarding evaporation, the area would be a desert. The total annual precipitation is light, but the illusion from low clouds, dense fogs, and soggy tundra is one of pervading wetness (Gyrc 1958). An average of 11.23 cm of precipitation falls annually at Barrow Village. About half of the annual precipitation comes in forms other than by direct rainfall from July through October.

Based on the total annual precipitation, Arctic climates are frequently referred to as "arid," but such a description does not apply to Barrow Village and probably not to the Arctic Slope as a whole (Britton 1957). Clebsch (1957) has shown that at least during the growing

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season on the Arctic Slope precipitation slightly exceeds evapotranspiration. The high relative humidity, over 90% during the summer months, offsets the drying action of high winds during this same period (Wiggins and Thomas 1962).

The annual amount of snowfall on the Arctic Coastal Plain is small. Strong winds blow and shift the snow over the landscape, blowing some areas completely bare of snow, and piling large drifts in protected lees. Snow depth increases as the Foothills and Brooks Range Provinces are approached. Britton (1957) during one winter of study estimated an average maximum snow depth of 10 inches (25.4 cm) occurred along the northern coast of Alaska. This snow depth increased to 16 inches (46.6 cm) a few miles inland. An annual snow depth of 10 to 15 inches (25.4 to 38.1 cm) was encountered on the Teshekpuk Lake Section during the white fox studies. Wiggins and Thomas (1962) discuss the adverse effects of scant snow cover for protection of plants on the Arctic Slope.

High winds during summer months are responsible for considerable wind erosion on the Arctic Slope. The development of extensive dunes along the banks of most of the larger rivers of the Arctic Slope and along several of the smaller ones testifies to this action (Wiggins and Thomas 1962). Annual mean wind speeds between 16 and 22.4 km an hour occur at Barrow Village. Maximum wind velocities of over 80.5 km an hour have been recorded from this same area.

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Vegetation

The vascular flora of the Arctic Slope has been treated extensively by a number of botanists (Anderson 1959; Hultén 1941-1950; Spetzman 1951, 1956; Britton 1957; Wiggins and Thomas 1962). Spetzman (1951) conducted the first extensive study of the entire area. He noted a flora of 439 species, subspecies, and varieties within the three physiographic units of the Arctic Slope. Porsild (1957) mapped some of the distribution of Arctic Slope plants which occurred in common with the 340 species known to be present in the Canadian Arctic Archipelago. Wiggins and Thomas (1962) have published the most recent, comprehensive work on the flora of the Arctic Slope.

The vascular flora of the Arctic Slope consists of 53 families and 150 genera (Spetzman 1951). Ten of these families comprise 70% of the existing flora with five families: Compositae, Cyperaceae, Poaceae, Brassicaceae, and Caryophyllaceae each being represented by at least 25 species (Spetzman 1951). *Carex*, *Salix*, *Saxifraga*, and *Potentilla* contain more species than do any other genera found on the Arctic Slope.

The richness of the Arctic Slope flora decreases as the northern coast of Alaska is approached. About 250 species of plants have been recorded from the Umiat region, while only 150 species are known from the Arctic Coastal Plain (Clebsch 1957; Spetzman 1951).

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Approximately 100 species have been collected in the immediate area around Barrow Village.

The complete absence of the tree growth form on the Arctic Slope is a conspicuous character. Low willow shrubs (Salix spp.) provide the only tall plant cover on the Teshekpuk Lake Section. These shrubs seldom reach heights of more than 1 m. Clebsch (1957) noted a shift in dominance from shrubs to graminoid species from the Meade River northward to Barrow Village. He correlated the distribution of these forms with an environmental gradient. Decreasing surface age of the several belts of land elevated successively above the sea raise the question of whether time has been sufficient for northward migration and establishment of a complete complex of floristic elements on the Arctic Slope (Britton and Major 1958 in Britton 1957).

The following outline denotes the major habitat types of vascular plants on the Teshekpuk Lake Section of the Arctic Coastal Plain (Spetzman 1951; Britton 1957; Wiggins and Thomas 1962):

A. Strand Vegetation
B. Beach Vegetation
   1. coastal
   2. raised inland
C. Lake Vegetation
   1. aquatic
   2. transitional
   3. shoreline
D. River Vegetation
   1. aquatic
   2. transitional

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3. shoreline
    a. cut-banks
    b. mud flats
    c. sand bars
    d. gravel bars
    e. alluvial fans
    f. oxbows

E. Creek Vegetation
1. aquatic
2. transitional
3. shoreline

F. Temporary Pool Vegetation
1. flooded watercourses
2. polygon pools

G. Marsh Vegetation

H. Bog Vegetation

I. Dry Ridge and Low Mound Vegetation
1. polygon ridges
2. sand dunes and sand bluffs
3. low mounds
4. hard, flat benches

J. Minor Vegetation Habitats
1. abandoned village sites
2. camp sites
3. vehicle trails
4. seismic shot holes
5. drained lakes
6. animal burrows
7. caribou migration trails

Low mound vegetation (I. 3.) was studied to determine if any changes in vegetation type were produced by the location of white fox dens in the low mounds. A description of this vegetation pattern and its changes is found in the section dealing with the den ecology of the white fox.

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HISTORY OF THE ALASKAN WHITE FOX FUR INDUSTRY

It was Alaska's natural wealth of furs, particularly those of the sea furbearers, that first brought the white man to this part of the world (Rogers 1962). The earliest to arrive were the Russian promyshlenniki, drawn by the large sea otter (*Enhydra lutris*) and fur seal (*Callorhinus alascanus*) populations. Spanish, French, English, and American traders and adventurers followed the Russians, and all began the well-documented exploitation of the sea otter, fur seal, whale, and walrus (*Odobenus rosmarus*).

The first authentic list of fur shipments from Alaska was compiled at the beginning of the nineteenth century by a Russian Navy lieutenant, Vassili Berg (Petroff 1898). He had access to the archives of Petropavlovsk, Nishnekamchatsk, Bolsheretzk, and Okhotsk, and recorded the Alaskan furs received in these ports during 1745-1797. Siberian traders were shipping pelts of the blue or maltese arctic fox as early as 1745, but not until 1798 do the earliest records occur of the white fox in the Russian fur trade.

The Russian-American Company, established in Alaska in 1797, periodically published reports of furs it exported from Alaska. These records furnish the best available information about the fur harvest in Alaska from 1797 until 1867 (Table 2). For several reasons these data

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Table 2. Number of furs shipped from Alaska from 1745 to 1880[1]

Fur	1745-1867[2]	1867-1880[3]	1745-1880[4]
Sea otter	260,790	52,491	313,281
Fur seal	3,354,478	1,277,333	4,631,811
Land otter	2,444,538	25,331	269,869
Beaver	413,356	58,258	471,614
Black fox	83,593	9,302	92,895
Cross fox	102,410	25,624	128,034
Red fox	147,917	114,633	262,550
Blue fox	204,791	11,927	216,718
White fox	45,891	15,804	61,695

[1] Petroff, Ivan. 1898. Report on the population, industries, and resources of Alaska _in_ Seal and Salmon Fisheries and General Resources of Alaska. 55th Congress, Doc. No. 92, House of Representatives. Vol. 4, pp. 167-450.

[2] Harvest of Siberian traders, Shelikof Company, and Russian-American Company.

[3] Harvest of American traders only.

[4] Total harvest of all traders recorded between 1745-1880.

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must be considered as a minimum estimate of the actual fur harvest. These totals do not compensate for any losses of pelts that must have occurred from shipwreck, or spoilage of pelts; nor do they include the number of pelts taken by illegal trading of the independent traders operating along the arctic coasts (Petroff 1898). There is no accurate estimate available on the amount of illicit trade that was occurring in Alaska, but Petroff (1898) states that "From the persistency with which these men continue to assume the risks of this unlawful trade... both its volume and profit are large."

After the purchase of Alaska in 1867, average prices of all furs increased greatly (Tables 3 and 4). The low Russian fur prices were the result of little or no outside competition, while the sharp rise of fur values after Alaska's purchase must be attributed to the increased competition between traders. Because of this competition, the purchasing power of money did not decrease proportionately to the increasing fur prices. This allowed an economically healthy fur trade to develop in the newly acquired United States territory of Alaska.

White fox pelts rose in value 900% after 1867, increasing from an average price of $.20 to $2.00 per pelt. At this same time, the average price of a white fox pelt on the London fur market was approximately $3.00. The low dollar value of this fur during this period of relatively high prices for other furs probably was caused by fashion's

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Table 3. Comparison of Russian, American, and English fur prices[1]

Fur	Average price per pelt in $		
	Russian[2]	American[3]	English (London)[4]
Sea otter	10.00	60.00-100.00	100.00
Land otter	.60	2.50- 3.00	3.00
Black fox	2.00- 3.00	10.00- 40.00	30.00
Cross fox	.60	2.50- 3.00	3.00
Red fox	.60	1.00- 1.50	1.50
Blue fox	.80	3.00- 4.00	4.00
White fox	.20	2.00	3.00
Beaver	.60	2.00- 3.00	3.00
Mink	.05	.20	.30
Marten	.10	3.00- 4.00	3.50
Fur seal	-	-	15.00
Muskrat	-	-	.10
Lynx	-	-	3.00
Black bear	-	-	5.00
Brown bear	-	-	2.00

[1] Petroff, op. cit. (Conversion to dollars by Petroff).

[2] Average fur prices, Russian Alaska, 1860's.

[3] Average fur prices, Alaska, 1880-1881.

[4] Average fur prices, London, England, 1880-1881.

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Table 4. Average value of furs shipped from Alaska during 1870 to 1880[1]

Fur	Average value of pelt in $	Total value
Sea otter	60.00	$2,416,980.00
Land otter	2.50	47,410.00
Beaver	2.50	103,042.50
Black fox	15.00	104,880.00
Cross fox	2.50	48,525.00
Red fox	1.00	82,919.00
Blue fox	2.00	15,016.00
White fox	1.00	11,492.00
Black bear	3.00	2,457.00
Brown bear	1.50	7,810.00
Mink	.20	14,242.60
Marten	2.00	163,218.00
Muskrat	.05	2,516.00
Lynx	2.00	12,624.00
Wolf	1.50	631.50
		$3,033,764.20

[1] Petroff, <u>op</u>. <u>cit</u>.

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disinterest in the fox pelt. The fur's low durability, only 40% of that of sea otter fur, was also a liability. White fox fur shows a marked depreciation in quality after being used for several years (Bachrach 1953).

It was in conjunction with the whaling industry that the white fox fur trade developed in northern and western Alaska. American whalers first appeared off the Alaskan coast about 1820, and in 1833, a Yankee whaler stopped at Sitka, Alaska, to recruit Aleuts for whaling in the arctic waters (Hulley 1958). Charles D. Brower began trading with the natives along the arctic coast in 1882, and in 1884 established the Cape Smythe Whaling and Trading Company at Barrow, Alaska (Brower 1942). He first began buying a few white fox furs in 1882 but intensified this fox trading in the early 1900's after commercial whaling ceased to be economical.

Commercial whaling reached a high in the Barrow, Wainwright, Point Hope, and Point Lay areas in 1900, and then suffered a slow, continuous decline until its eventual end in 1910 (Brower 1942; Spencer 1959). A considerable number of white fox pelts may have been obtained by whalers along the arctic coast during their operations in that area, but no reliable records exist showing the volume of this trade.

Beginning after World War I, fox trapping became the primary

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economic activity along the arctic coast, replacing the lost whaling revenues. It continued to be the most important source of income for the next 12 or 13 years in this area (Spencer 1959). The 1920 sharp increase in fur values, due primarily to the economic boom in luxury goods following World War I, prompted the Eskimos to begin intensive white fox trapping along the arctic coast of Alaska. Spencer (1959) states that during the 1920's white fox pelts sold for an average price of $50.00 each. Brower (viva voce) states that $55.00 was the top price paid for fox pelts to native trappers by the Cape Smythe Whaling and Trading Company during that decade. One native trapper is reported to have earned $8,000 during the 1927 trapping season, mainly from white fox furs, indicating possible incomes existing under the inflated fur prices. This increased economy replaced the lost whaling revenues and began to raise the Eskimo standard of living. Spencer (1959) noted that during this period there was a marked increase in large boats, as well as the beginning of the native stores in Barrow Village.

In 1929, the Cape Smythe Whaling and Trading Company purchased 12,000 white fox pelts from the Arctic Slope, paying $35.00 for the best pelts (Brower viva voce). These trading posts bought furs at Barrow Village, Barter Island, Beechey Point, and Point Lay, and were the only established stores in the area until the Native Cooperative

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Stores developed in the late 1920's. This was the largest number of white fox furs ever purchased in one year by Brower's company during its many years of trading in northern Alaska.

The 1929 depression destroyed the market value of white fox and other furs, as well as halting the rising economic status of Eskimo trappers in northern Alaska. Some residents of Barrow also maintain, even today, that it was the importation of Russian furs that helped, if not initiated, the fall of fur prices in 1929. However, fox imports from Russia remained almost constant during the 1920's and early 1930's and do not show an expected increase if the fur market was truly glutted during this period with Russian fox furs (U.S. Dept. of Commerce 1930, 1936).

White fox pelts in 1931 brought the trapper only $5.00 or less. Fox trappers, formerly wealthy during the fur boom of the 1920's, were forced to revert to subsistence hunting and depend upon sea mammals for food. A few Eskimos continued to trap, but the combination of low prices and light trapping pressure resulted in a greatly reduced fur harvest of this species for the following years. White fox pelts have never again been as valuable as during the fur boom of the 1920's.

Economic depression and limited fox trapping continued in the Barrow area until 1946, when the United States Navy began extensive

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oil explorations on the Arctic Slope. This operation provided full-time employment for approximately 75 to 80 Eskimos from 1946 until oil exploration ended in 1952 (Roberts 1954; Spencer 1959). It was during this period, when many Eskimos were employed full-time, that one of the lowest recorded Alaskan white fox harvests occurred. Fur records show (Appendix II) that only 654 white foxes were exported from Alaska in 1951 in comparison to the highest number of white foxes ever exported, 16,658 in 1925. If these figures are correct, it appears that the low pelt value and high Eskimo employment may have been important factors in reducing the fox harvest in northern Alaska.

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PRESENT STATUS IN ALASKA

Harvest Statistics

Considerable variation exists in the yearly harvest of Alaskan white fox (Fig. 7). Between 1912 and 1963, Alaska sustained an average annual harvest of 4,072 white fox pelts. The largest harvest of white fox, 16,658, occurred in 1925, and the lowest harvest, 460, in 1956. Between 1960 and 1962, 4,277 white fox furs were reported shipped to fur buyers, almost all of whom lived outside of Alaska. These sales, 86% of the estimated total harvest for the period 1960 to 1962, indicate that most Alaskan white fox furs are sold and utilized outside of Alaska.

There is little local market for this species now, other than for use in the manufacture of tourist souvenirs, and decorative trims for parkas, mukluks, and slippers. With the existing economic conditions, it is doubtful that a local market of significant size for white fox furs will soon develop in Alaska.

Fur records are best considered as indications or trends of the fur picture in Alaska, rather than an exact record of fur harvest. Fur export records and fur buyer reports, required by law when purchasing or exporting Alaskan raw furs, are used to compile Alaska's fur harvest data. Comparison of these records shows that the fur buyer

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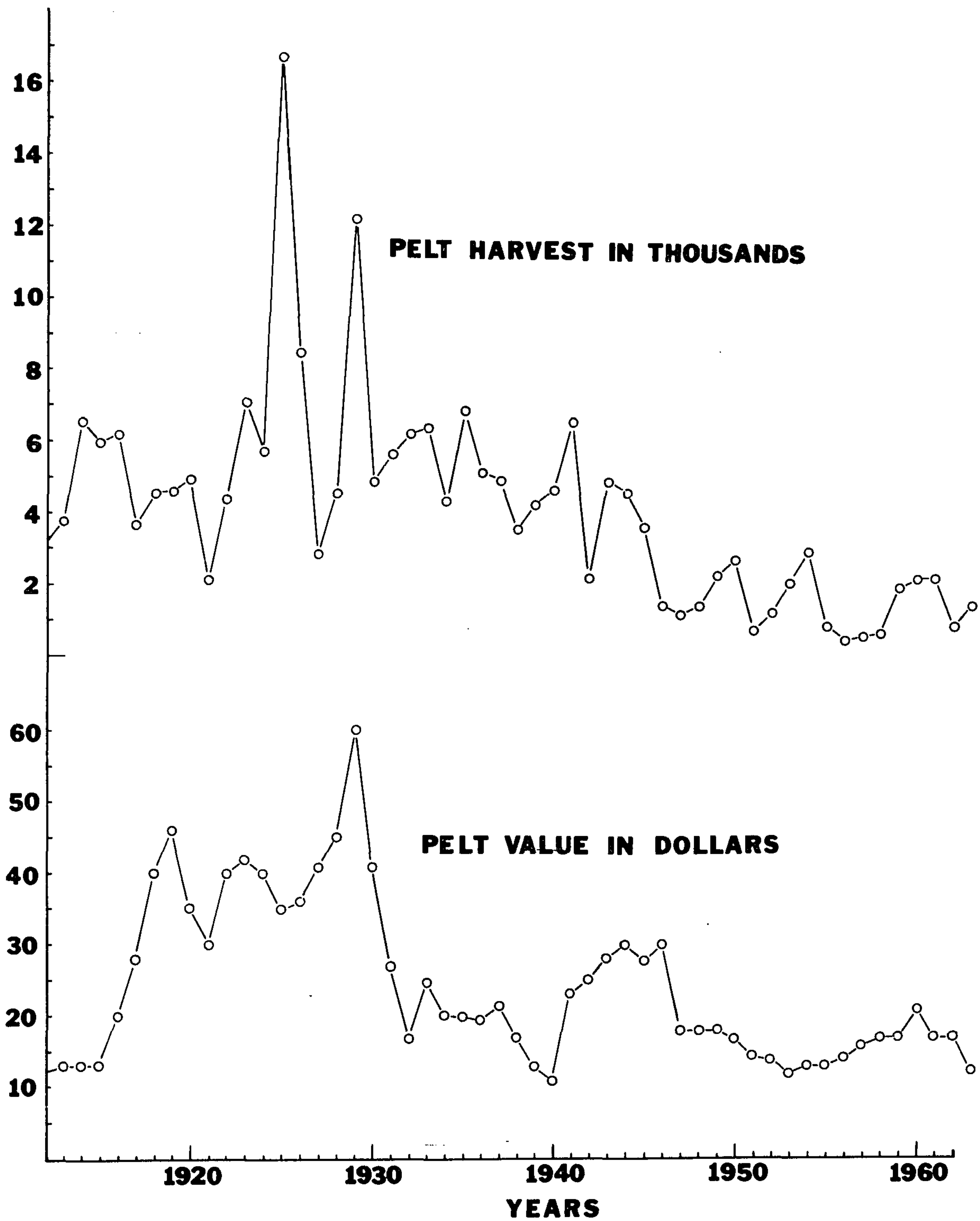

Fig. 7. Annual average white fox harvest and pelt values in Alaska from 1912 to 1963.

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reports are consistently lower in fur harvest estimates than are the fur export records.

Not all Alaskan furs are shipped or sold during the same trapping season in which they were taken. However, at Barrow Village, almost all furs were either sold during the trapping season or shortly after its end.

The practice of reporting fur take wherever trappers purchase their trapping licenses can produce a distorted idea of trapping pressure and yield from the fur districts. Furs may be sold several districts from their source, again producing misleading fur harvest data. Fur harvest is reported on a calendar year, rather than on a fiscal year basis. Variations due to estimating the portion of fur harvest occurring during various times of the trapping season, and the conversion of these data to a yearly report, may produce discrepancies in the actual fur harvest pattern.

Reluctance by trappers to keep accurate records of their fur take, and opposition to reporting this annual take are often based on the fear of increased trapping restrictions. This hinders the development of accurate harvest data. Home usage, loss from predation on trapped furbearers, improper care of pelts, and the failure to sell unprime, small, or low-quality pelts to fur buyers all tend to alter the validity of existing harvest statistics.

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Distribution of Harvest

In determining the present distribution of the white fox harvest in Alaska the state was divided into three separate geographic areas: the Arctic Slope, encompassing the area north of the crest of the Brooks Range; Islands, primarily those located in the Bering Sea off the western coast of Alaska; and western Alaska, that portion of the state bordering on the Bering Sea and extending south of the southern boundary of the Arctic Slope into the Bristol Bay region.

The Islands produce the highest catch of white fox per unit area of any of the three geographic divisions. Based on data from the 1959-62 fur export records, 31%, 898 pelts, were shipped from the Islands, while 42%, 1,238 pelts, were exported from the Arctic Slope. The remaining 798 pelts, 27% of the total white fox exported during 1959-62, were obtained from western Alaska. Table 5 provides data on the yearly fox harvest in these areas from 1959 through 1962.

St. Lawrence Island produces more white fox furs than any of the other Alaskan islands within the fox's range. The harvest of this species both on the Arctic Slope and in western Alaska is concentrated near the coast.

Harvest on the Arctic Slope

To determine the white fox harvest in northern Alaska, a store tally was organized during 1960 to 1963 in the stores buying furs at

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Table 5. Distribution of the white fox harvest in Alaska during 1959-1962, based on fur export records of the Alaska Department of Fish and Game

Area	Harvest	Per cent
	1959-1960	
Arctic Slope	890	48
Islands	595	32
Western Alaska	379	20
	1,864	100
	1960-1961	
Arctic Slope	153	52
Islands	47	16
Western Alaska	94	32
	294	100
	1961-1962	
Arctic Slope	195	25
Islands	256	33
Western Alaska	325	42
	776	100
	1959-1962	
Arctic Slope	1,238	42
Islands	898	31
Western Alaska	798	27
	2,934	100

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Wainwright and Barrow Village, Alaska. The store owners conducted this count, tallying the sex and number of white fox pelts purchased each month during the trapping season and on into the spring after the close of the trapping season. As shown in Table 6, 1,824 white fox pelts were purchased by these stores during these three trapping seasons. These pelts comprised 43% of the total estimated harvest for the last three trapping seasons in Alaska, 62% of the last two trapping seasons, and 34% of the 1963 trapping season.

The most interesting result of this census is that in 1962 the store tally of white fox from Barrow Village and Wainwright of 857 pelts exceeded the published state harvest of 776 pelts. Evidently, not all fur sales and shipments at Barrow Village and Wainwright were reported to the Alaska Department of Fish and Game. Contact with those conducting the store tally at Barrow Village and continued correspondence with the men at Wainwright leave little doubt that the store tallies were very accurate. About 90% of the foxes taken by Barrow Village trappers are sold at the local stores, with the remainder being used in local homes or sold outside of Barrow Village to itinerant fur buyers. A few pelts may be sold to tourists during the summer months.

Value of White Fox Furs

Trapping effort showed a direct relationship to furbearer value and variations in the annual harvest of white fox also reflected these fur

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Table 6. Harvest of white fox at Barrow Village and Wainwright, Alaska (1960-1963), based on the number of fox skins purchased by the village stores[1]

	Village						
	Barrow			Wainwright			
Year	Male	Female	Total	Male	Female	Total	Total harvest
1960-61	225	264	489	[2]	[2]	[2]	489
1961-62	110	116	226	340	291	631	857
1962-63	61	54	115	218	145	363	478
Total	396	434	830	558	436	994	1,824
Average	132	145	277	186	145	331	608

[1]Data collected by store owners at respective villages.

[2]No record kept at village store during 1960-1961.

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prices (Fig. 7). White fox pelts have reached values over $40.00 but usually sell for less than $20.00 a pelt. Table 7 shows the value and harvest trends in the Alaskan white fox harvest from 1912 through 1963. Between 1912 and 1963, an average price of $24.18 per pelt was maintained with the highest price, $60.25 per pelt obtained in 1929, and the lowest price, $12.50 per pelt, received in 1963.

Pelt prices for white fox pelts at Barrow Village have declined in recent years. In 1959-60, 681 pelts brought an average price of $30.00 cash or credit at local stores but in 1960-62 sold for $17.00. Pelts sold to tourists bring an average price of $20.00.

Although advertised values for raw furs may show general price trends, these prices do not accurately indicate potential trapper income. Few furs succeed in meeting the top grades of the fur buyer and thus actually receive the premium prices advertised in fur buyer brochures. Most furs are graded into middle and low fur grades. White fox pelts from northern and western Alaska receive higher prices per pelt than do those taken in the lower Yukon-Kuskokwim River areas. Increased pelt size and quality of fur apparently are responsible for this differential price.

Economic Importance of the White Fox

Determination of the white fox's economic importance in comparison to other furbearers in Alaska is based on two factors:

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Table 7. Comparison of past white fox pelt values with the existing value during 1952-1963

Date	Average harvest	Average pelt value in $	Relation to: Past decade	Relation to: 1952-1961
1912 to 1921	4,536	25.04	no data	+
1922 to 1931	7,247	40.94	+[1]	+
1932 to 1941	5,262	18.78	-[2]	+
1942 to 1951	2,466	22.65	+	+
1952 to 1963	1,442	15.28	-	no data

[1] + increase over past value.

[2] - decrease over past value.

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value of pelt, and size of harvest. Based on the 1925 to 1962 summary of fur values and harvest (Table 8), the white fox ranks fourth in average pelt value and sixth in over-all harvest value when compared with the other ten common land furbearers in Alaska.

Only 5 of the 11 economically important land furbearers found in Alaska regularly occur on the Arctic Slope: red fox, white fox, wolf (Canis lupus), weasels (Mustela spp.), and wolverine (Gulo luscus). Although these furbearers occur throughout the Arctic Slope, all, except the white fox, either sparsely populate the area, or tend to concentrate in the foothills and mountains of the Brooks Range. Few trappers penetrate the latter areas. Adverse winter conditions and the distance from villages, most of which are located along the coast of northern Alaska, restrict intensive trapping in the interior portions of the Arctic Slope.

Thus, on the coastal plain of northern Alaska, only the white fox occurs in large enough numbers to be subject to an intensive trapping effort. Consequently, because of a relatively high pelt value, periodic high populations, and availability to local trappers, the white fox is the only furbearer of significance to trappers on the Arctic Slope of Alaska.

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Table 8. Average annual fur harvest within Alaska from 1925 through 1962[1]

Furbearer	Average price per pelt in $	Average yearly harvest	Average harvest value in 1,000's of $
Mink	20.23	36,640	741
Beaver	23.10	18,070	417
Muskrat	1.23	207,207	253
Red fox	13.16	11,014	145
Marten	28.89	5,187	139
White fox	22.96	3,888	89
Lynx	28.60	2,293	66
Otter	20.80	2,805	58
Weasel	1.38	8,185	11
Wolf	20.50[2]	642	45
Wolverine	17.84	378	6

[1]Koontz, K. 1963. Small game and furbearers of the Rampart Dam Impoundment Area. Unpublished Job Completion Report (Contract No. 14-17-0005-35) in Alaska Coop. Wildl. Res. Unit files, Univ. of Alaska, College, 38p.

[2]$50.00 bounty payment added to average pelt price to determine over-all harvest value.

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ECONOMIC IMPORTANCE AT BARROW VILLAGE, ALASKA

Barrow Village's economic structure was studied in three ways: personal interviews with residents; questionnaires mailed to village trappers; and a review of the pertinent literature.

Description of Barrow Village

Barrow Village, 71°17'18" N, 157°16'16" W, is 528 km north of the Arctic Circle on the northernmost point of land in the United States. It is the largest Eskimo village in North America, and in 1960 had a native population of 1,314 (U.S. Bureau of the Census 1961).

Six km north of Barrow Village, a large camp has been built, composed of the Arctic Research Laboratory, operated by the U.S. Navy and the University of Alaska, and two construction companies, Puget Sound and Drake, and the Federal Electric Company, suppliers of the Distant Early Warning (DEW) sites in northern Alaska. This camp provides considerable cultural and economic exchange with Barrow Village. It gives Barrow Village residents employment and a market for goods and services throughout the year.

The following description of Barrow Village was developed during the field work in that area from September, 1961 until March, 1963 and reflects conditions in the village at that time.

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Barrow Village homes, one or two story wood frame buildings, are scattered in a helter-skelter fashion over the low tundra along the Arctic Ocean. The village has no organized streets, water, gas, or sewage systems. A variety of facilities exist in the village: five general stores, two summer hotels, two restaurants, an airline office, a bank, two churches, a movie theater, and a combination fire hall-community building. Federal agencies, including weather bureau, post office, Public Health Service (PHS) hospital, and the Bureau of Indian Affairs (BIA) school, provide additional services for residents.

Barrow Village, incorporated as a fourth class village, secures revenues with a 2% sales tax on local business transactions. A seven member village council, elected yearly with one of its members acting as president, provides local government. A state-appointed deputy magistrate and a city clerk complete Barrow Village's government. A member of the State Police is stationed at Barrow Village and attends to law enforcement.

Supplies reach the village by either commercial airline, or annual Alaska Native Service (ANS) freighter which arrives during the short ice-free period in mid-August. One airstrip now serves Barrow Village and the U.S. Navy camp, but another is being built on Barrow Village's outskirts. Completion of the new airstrip may result in a reduction of air freight charges, now expensive at $.15 per pound

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from Fairbanks, Alaska, and improve air service to Barrow Village.

Village electricity is provided intermittently by several groups. Unsuccessful attempts have been made by residents to establish a dependable power source by forming an electrical cooperative in the village. No modern sewage or water systems are present at Barrow Village, making sanitation a problem. Water is hauled to local homes from fresh-water lakes 4.8 to 8 km east of the village. Village homes are heated either by fuel oil or low grade coal which is mined by users at Meade River coal mine. The development of nearby natural gas reserves would provide cheap power and heat for Barrow Village residents. This would have a profound effect on the economic climate, decreasing the second highest living expense, heating, and enabling Barrow Village's limited incomes to buy more material goods per dollar than is now possible.

Extensive changes are being planned and have been begun by private and government agencies at Barrow Village. Complete village reorganization is planned by the BIA with the end result being a modern city in northern Alaska. Natural gas resources near the village have been made available by congressional action for use by Barrow Village residents, and the necessary technical planning and research for gas installations is underway at the University of Alaska in cooperation with the BIA. Village reorganization, the first necessary step in the modernization of Barrow Village, is needed to permit the

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safe distribution of natural gas into local homes. Modern water and sewage systems will also be installed in the homes after natural gas installations have been completed. High school construction will begin in the summer of 1964 and will provide educational facilities for Eskimos in northern Alaska. Completion of a new electrical system at Barrow Village is pending. A disagreement exists over whether a private group, Golden Valley Electrical Association, Fairbanks, Alaska, or the BIA will supply power to the area. These changes may result in a totally different economic and sociological climate at Barrow Village than existed during 1961 to 1963.

The 1960 census provides the best data on Eskimo economic and social conditions in Election District 21. A sparse native population characterizes the area; the 1960 Eskimo population in Election District 21 was 1, 605. This district, including 58, 512 square miles of northwestern Alaska, contains the only two large Eskimo villages found in northern Alaska, Barrow Village and Wainwright. About 50% of thepopulation of Election District 21 is concentrated at Barrow Village so the census information for this district is assumed to reflect accurately conditions within that village.

The Eskimo population is rapidly increasing. Older Eskimos have little formal schooling, but education levels are rapidly rising among the younger residents. A high unemployment rate exists for

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Eskimo workers; and compared to the American national average, most Eskimo families and individuals have a very low dollar income.

Economic Structure of Barrow Village

Barrow Village, like other native villages in Alaska, is in a state of economic and social change. This change, from independent subsistence hunting to reliance on other people for basic needs, has produced a complex mosaic of social and economic reactions in the Eskimo community.

No native village, regardless of similarities in location, size, or past history, can safely be compared economically or sociologically with another. Each has evolved separately and uniquely in the characteristic harsh environment of northern Alaska and under varying degrees of contact with white culture and values.

Woolford (1954) states that some of the variables affecting a native economy are: availability and extent of the wildlife resource; availability and extent of local and outside employment; and the degree of dependence upon government aid for the relief of children, the aged, and the unemployed. Geographic location, tribal customs, length of association with whites, educational advancement, and general health also influence village economy.

Barrow Village falls into the Class 2 village used by Woolford:

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> In this category are the villages characterized by long association with the whites. Local industries and activities of the whites have provided a substantial amount of seasonal employment and to lesser degree, continuous employment. Villagers have become dependent upon one another for services such as furnishing and hauling water and fuel. The wildlife resource is heavily utilized and all available sources of government disbursements for relief are avidly tapped....

In a generation, Barrow Village has changed from almost a total hunting economy to one where only 25% depend primarily on hunting (Killiktokti 1962). Now, Barrow Village's economy is based on federal government operations: the U.S. Navy's Arctic Research Laboratory, U.S. Air Force, Federal Electric Company, Puget Sound and Drake, U.S. Weather Bureau, BIA aids, and state welfare checks. Table 9 gives detailed information on the cash income at Barrow Village. Federal and state welfare aids comprise a large part of the annual income. Barrow Village's unearned income for 1962, from unemployment compensation, social security, BIA general assistance, and welfare, was $187,600 (Table 10). Each Barrow Village family received an average unearned income during 1962 of $1,042.

Barrow Village's living costs are very high. A cost-of-living estimate was obtained from Barrow Village prices listed for basic supplies, food, fuel, and ammunition, that are required for minimum family subsistence. Twelve food items cost $27.70 at Barrow Village, but only $12.96 in Seattle, Washington. Computed at Barrow Village prices, 18 basic items cost $40.20 but were only $28.70 in Fairbanks,

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Table 9. Summary of economic survey of Barrow Village, Alaska, during 1961 (Bowler 1962)

BARROW VILLAGE FACTS

	1958	1961
Total number of families	169	217
Total population	1,500	1,529
Eskimo (1961) 1,502		
Non-Eskimo (1961) 27		
Total number of private businesses	19	22
Total income	$612,774	$1,166,387
Total fuel expenditures	$155,107	$ 249,374
Present and future school attendance		
Present-Barrow Native School, beginners through sixth grade	346	
Students sent outside of village	152	
Total students	498	
Future estimates-Barrow Native School,		
Grades 1-8 1962-1963	470	
Grades 1-12 1965-1966	700	

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Table 9. (Continued)

SOURCE AND AMOUNT OF OUTSIDE INCOME TO BARROW VILLAGE, 1961

	Gross
Arctic Research Laboratory	
Native payroll	$144,000
Baby sitter	3,750
Purchases	
Arctic Research Laboratory	3,000
Arctic Research Laboratory personnel	3,000
Wein Alaska Airlines and Alaska Communications Service	66,000
Weather Bureau	
1 native employee	10,000
6 non-native employees spent 10% of pay in Barrow Village	5,500
Public Health Service	
22 employees, native	144,000
11 non-native employees spent 10% of pay in Barrow Village	6,000
Bureau of Indian Affairs	
Total staff payroll $113,272 (estimate 60% spent in Barrow Village	67,963
PD & C Construction, 45 natives employed at varying periods	155,250
Bureau of Standards	
1 native employee	5,500

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Table 9. (Continued)

INCOME FROM TOURIST ACTIVITIES AT BARROW VILLAGE, 1961

Native Store, "Top of World Hotel"	$ 14,221
Brower Hotel (estimated)	14,000
Native Store Cafe (only open one meal per day for tourists only)	9,387
Other restaurants for tourists and hunters	90,000
Kriers Al Hopson Steve Hopson Browers Cafe	
Gift shop, Glady's Originals	50,000
TOTAL	$177,608

STATE AND FEDERAL AID AND RELIEF, 1961

BIA Branch of Welfare	$ 23,000
Social security	19,200
State unemployment benefits	21,200
Other state aids	52,856
TOTAL	$115,456

TOTAL OUTSIDE INCOME AT BARROW VILLAGE	$1,166,387
AVERAGE 1961 INCOME PER FAMILY AT BARROW VILLAGE	$ 5,370

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Table 10. Sources and amount of unearned income at Barrow Village, Alaska, during 1962

Unemployment compensation	$ 53,373
Social security	22,800
Bureau of Indian Affairs general assistance	24,535
Welfare payments	
Old age assistance	29,652
Aid to the blind	1,176
Aid to dependent children	56,064
TOTAL	$187,600

[1] Information from personal communications with various agencies responsible for the administration of this aid.

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Alaska. Approximately a 40% increased cost-of-living exists in the Barrow Village community over that of Fairbanks, Alaska. But, all items are not equally inflated in price. Food prices are 14% above Fairbanks prices, ammunition costs were equal, and Barrow Village fuel costs were 88% higher than Fairbanks fuel costs.

Food, heating, and clothing, in that order, are the most expensive living costs at Barrow Village (Spencer 1959). Because most Eskimo families do not use a planned budget, it is difficult to estimate the income needed for a satisfactory living standard at Barrow Village.

Spencer (1959) learned during his 1952-53 Barrow Village study that a family of five, having an ample supply of game, could spend \$50.00 to \$140.00 a month on food, depending on how much the group was using introduced store foods. If no game was available, food costs could reach \$300.00 a month. Today, these prices would be slightly higher, reflecting the over-all cost-of-living increase throughout the state. Assuming the family purchased only staples, spending approximately \$40.00 a week, the yearly food cost for five persons at Barrow Village would be \$1,920.

An estimate of heating costs for a three-room frame dwelling is 5 gallons of fuel oil per day (Spencer 1959). Assuming that this full heating cost would be borne for 8 months, heating such a home would cost \$780.00 a year. Bowler (1962) estimates the annual heating cost

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of the families at Barrow Village to be $1,147 a year.

No accurate figures for the exact living costs or additional income received by Eskimo families for the sale of crafts, wild game, or subsistence gained by trading or working for needed items are available for Barrow Village residents. Eskimo generosity also provides for many of the less fortunate members of the Barrow Village community, but just what impact this action has on the area's economic picture is unknown. It may result in additional expenses for those families who are obtaining sufficient income to meet their needs, and could lower their standard of living accordingly. Van Stone (1962) reports this result in family interactions at Point Hope.

It is clear that most of Barrow Village's Eskimo families have low dollar incomes today while facing very high living costs. Dollar income does not always match dollar expenses, but the substitution of subsistence gains for monetary needs has helped shorten, if not bridge, this gap. Barrow Village is essentially functioning under two economies: a money economy and a subsistence economy. It is those families who can adapt to both systems that are enjoying a high standard of living in the village today.

Trends in Barrow Village's Economy

Increasing construction and oil exploration on the Arctic Slope will continue to provide more full-time employment for Barrow Village

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residents. During the winter of 1962-63, 40% of the Barrow Village men were employed full-time, and another 25% were employed part-time (Nayokok _viva voce_).

Due to increased employment, trapping effort for white fox and other furbearers should continue to decrease. Market hunting and the sale of game, mainly seals and caribou (_Rangifer arcticus_), to employed men who lack time to hunt for their own families, may continue to provide increasing income for the remaining subsistence hunters of the village. Only a marked increase in fur prices, raising trapping income to a comparable level with available construction incomes, could cause the resumption of intensive fur trapping at Barrow Village.

Importance of White Fox in the Barrow Economy

Few Barrow Village men are now trapping regularly. During the 1962-63 trapping season, 39 trapping licenses were sold at the Barrow Native Cooperative Store, the only one in the village selling them. Of these 39 men, 25 answered the trapping questionnaire that was mailed to each. Of those answering the questionnaire, only six men stated they were trapping regularly, while five more reported that they were trapping only part-time. Nayokok (_viva voce_) estimated that there were no more than 10 to 20 men trapping full-time in the village during the 1962-63 season. Similar estimates were also given by other residents in the area (Brower _viva voce_; Hopson _viva voce_). It is likely that no

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more than 20 men are intensively trapping white fox in the Barrow Village area today.

Full-time employment and poor health were the main reasons given for not trapping regularly, with the low price of fur and bad weather also mentioned as primary reasons for not trapping. Those trapping part-time were all employed full-time by various agencies around the Barrow Village community.

Few young men are now trapping in the Barrow Village area. The average age of the 36 Eskimos purchasing trapping licenses at Barrow Village was 42 years (24-70). The average age of the 11 men trapping either full- or part-time was 47 years. As noted by Hughes (1960) trapping skills are not being passed on to the young men. Unless raised in a subsistence hunting and trapping environment, a young man who has no guidance or previous experience in fur trapping has only a 50:50 chance of succeeding financially at trapping (Edwardson *viva voce*).

A significant change in trapping procedure has developed since the 1920's when two or three families located a central trapping camp, 16 to 24 km from other similar camps along the coast, to trap white foxes (Jenness 1957). A radius of 8 to 11 km around the camp was trapped intensively, with each member of the camp trapping an equal portion of the surrounding area. Now, families remain at Barrow Village while the trapper sets and checks his traps on his trapline

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alone.

During the trapping season, an average of 73 traps (6-200) was maintained on traplines by Eskimo trappers of Barrow Village. Trapline lengths varied between 8 and 280 km, having an average length of approximately 101 km. Part-time trappers maintained shorter traplines, usually less than 16 km, using an average of 12 traps on each line. A description of Eskimo trapping techniques is given in Appendix III.

Three main forms of transportation were used by Barrow Village trappers to check traps: motor vehicles, such as snow travelers, "weasels", and snow mobiles (48%); dog teams (30%); and walking (22%). The longest routes traveled by dog teams usually ended approximately 120 km from Barrow Village, with the greater distances, up to 280 km of trapline, being completed with motor vehicles. Walking was confined to within an 8 km radius of Barrow Village.

Over many years, an average catch of 56 foxes per trapper was reported. Jenness (1957) reported that in the 1920's trappers took between 20 and 50 foxes during a season. Averages of 50 and 100 foxes per trapper are known from St. Lawrence Island (Hughes 1960). One trapper at Barrow Village, noted as one of the best in the village, took over 150 white foxes during the 1959-60 trapping season (Geist *viva voce*). Trapping success is dependent on a number of factors:

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skill of the trapper, density of foxes, weather conditions, length of trapline, and perhaps chance. With reasonable effort, it could be expected that in an average year a Barrow Village trapper would take around 50 white foxes.

The majority of trappers checked their traplines at least once a week (13 of 15) while only 1 out of 15 did not check his traps for at least a month after setting them.

White fox, red fox, wolverine, wolf, polar bear (Ursus maritimus), and dogs (Canis familiaris) were all listed as known predators on white foxes in traps. Losses due to this predation vary directly with the care a trapper exercises in checking his traps regularly, but most trappers lose at least 1 to 5 white foxes every year to this predation.

Thirteen trappers stated that they usually caught at least one or more unprime foxes, primarily young animals, during the first few weeks of trapping season. White foxes are usually prime until the 1st and 2nd week in April. Stains from the fat of sea mammals turn the white fur pale yellow, and badly stained fox pelts are often discounted by fur buyers up to 50% of their original value.

Home utilization of this species is low, consisting usually of 1 to 5 pelts per family. Ruffs and trim for clothing are frequently made from damaged pelts. These pieces sell for about $10.00, therefore salvaging some of the loss that might occur if these damaged pelts

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were sold intact. Families often keep damaged pelts for their own use rather than sell them for a low price.

During the study, the trapping of the white fox had little impact on the over-all economic picture of Barrow Village, Alaska. Fox trapping could become important again if the present high employment rates cease and/or the price of white fox furs again rises to the levels of the 1920's fur boom. In other villages of northern Alaska lacking employment opportunities, white fox trapping often is the only source of earned income for villagers during the winter months.

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PELAGE AND PRIMING SEQUENCE

Two different winter pelages, a blue and white phase, occur in _Alopex lagopus_ with about 99% of the foxes having the white winter pelage (Elton 1949). The blue phase is rare in the Central Arctic region of North America, and more common in the eastern Arctic, Greenland, and western Alaska (Anderson 1937; Fetherston 1947).

In Alaska, the blue phase predominates on the Aleutian and Pribilof Islands and the Alaskan Peninsula; but northward the blue is replaced by the white phase (Nelson 1887). Few blue foxes are taken at Barrow Village, but occasionally they are seen in the area (Brewer _viva voce_). During the study, no blue fox pelts were seen in either Barrow Village stores or trappers' homes.

Dichromatism

Preble and McAtee (1923) studied white fox dichromatism on St. George and St. Paul Islands in the Pribilof group, Alaska. They killed all the white foxes on St. George, permitting only blue fox to reproduce; while on St. Paul no selective killing of foxes occurred. Less than 1% of the fox offspring on St. George were white; while 17% of the fox offspring on St. Paul were white, indicating, as expected, that white fox dichromatism was controlled by genetic inheritance.

The two winter color phases of the white fox result from an

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autosomal recessive gene for white (Johnansson 1960). Breeding experiments with Alaskan blue and white fox produced no white offspring in the F_1 generation of a blue and white fox cross; while the F_1 of a white and white fox cross produced only white offspring. The white offspring of the white-white cross had many black-tipped guard hairs. Black-tipped guard hairs, possibly indicating a past genetic history linked to the blue phase of the white fox, were common in white fox pelts from the Barrow area, with 62% of the pelts having these black-tipped hairs.

Seasonal Pelage Patterns

The blue fox is brownish or sooty in its summer coat and becomes lighter in winter (Preble and McAtee 1923). The pelage of the blue fox pups approximates that of the adult blue fox.

In the white fox, three distinct pelage patterns have been noted: the pup pelage, the adult summer pelage, and the adult winter pelage.

Pup Pelage

At birth pelage of the pup is blue-grey to sooty black, never white (Freuchen 1935). Lavrov (1932) notes the dark dorsal stripe disappearing anteriorly on a mostly dark brown body with a white belly.

White fox pups approximately six weeks old are brownish-grey

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in color, being darkest over the back and upper part of the round, fluffy tail; and lightest over the lower legs and feet, with the fur having a fine, soft, silken characteristic of puppyhood (Soper 1944; Preble 1902). Most Barrow Village trappers indicated that pups become white later in the winter than do the adults; but the one young fox, a female, DLC-32, collected November 15, 1962, was almost as white as adult foxes trapped during the same period. This young fox had noticeable grey areas on the center of the back and tail but otherwise was in winter pelage.

Adult Summer Pelage

Wide variation exists in the timing of the white fox spring moult, but generally it extends from March or April until June or July (McEwen 1951). Pocock (1912), Lavrov (1932), and Barabash-Nikiforov (1938) give detailed descriptions of white fox hair replacement and pelage change during the spring moult.

In the Barrow area, bits of moulted fox hair were found clinging to den entrances and low brush during the last two weeks of June, indicating the spring moult was already well in progress. However, three foxes I saw on June 25, 28, and 29, 1962, near Camp I, still had predominately white pelages, although one animal was developing a noticeable black bar on its rump. On July 23, 1962, I saw a white fox in complete summer pelage at Camp II. On July 23,

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30, and 31, and August 2, 1962, all foxes observed had approximately the same complete summer pelage patterns consisting of a black face with dark bands on the shoulders and withers. These dark bands contrasted sharply with the bluish-grey remaining upper portions of the back and sides and the varying shades of brown to light grey coloring the body underparts. Dorsally, the tail was very dark, but became lighter ventrally.

<u>Adult Winter Pelage</u>

The fall moult, changing the brown-grey summer pelage to the pure white coat, begins in September and may extend until mid-October (Soper 1928; Lavrov 1932); November (Kirpichnikov 1937); or December (Dubrovskii 1937). Eremeeva (1956) found that the fall moult began as soon as the summer pelage had been completely acquired. Pocock (1912) gives a detailed description of the fall moult in captive white fox in London's Zoological Garden.

A general idea of the priming sequence of the white fox can be seen in a series of 11 pelts collected in the Barrow area between the latter part of September and December, 1960. The belly portion of the winter pelt first turns white in September, and then is followed by the rest of the fur with the center of the back, tail, and perhaps the backs of the ears last attaining a pure white color in December or January. Lavrov (1932) also noted that the back and tail are

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the last parts of the fox pelage to turn white during the fall moult.

Factors Influencing Priming

Detailed studies on factors influencing white fox priming are lacking; but probably climatic and geographical factors, as well as physical and physiological conditions all interact to govern the periodicity of priming in this species. Lavrov (1932) found differences in the time of priming between the fox of Novaya Zemlya and northwestern Siberia, indicating geographical influences; and Faester (1943) connected the warmer annual temperature in Greenland with the annual increase of white foxes taken in "summer skins". Eskimo trappers from the Barrow area also noted that a warm fall produced poorer fur during the coming winter trapping season, but no data exist to support this statement. The fact that fox pups change to winter pelage later than adults has already been discussed.

Physical Features of Barrow Pelts

Male fox pelts were easily separated from female pelts by the presence or absence of the penis scar which was found to be the only valid criterion for accurately sexing white fox pelts.

Generally, male white fox pelts were slightly larger than female pelts and usually had longer tails. The range of lengths of pelts of

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males was 68. 6 to 121. 9 cm. Minimum and maximum lengths recorded for female pelts were 66. 0 and 116. 8 cm.

No definite difference between male and female pelt coloration was noted. Blacktipped tails occurred in 94% (112 of 119) of the pelts; and blacktipped guard hairs occurred in 62% (75 of 121) of the pelts. Only 20% (21 of 107) of the pelts had totally white ears, with the others varying in shades of grey. Considerable variation occurred in the color of mystacial vibrissae (Table 11).

Applicability of Present Trapping Regulations

Although more study of pelts and the collection of a series of pelts from all months of the year is needed to establish the definite limits and periodicity of the biological priming sequence in the white fox, the present trapping regulations apparently prevent the taking of many economically unprime foxes in the Barrow area. It should be understood that biological primeness may or may not equal economic primeness of the pelt. Barrow Village trappers indicated that under the existing trapping schedules, with the usual trapping season opening December 1 and closing in April, a few unprime foxes were taken during the first portion of the trapping season and that after April 1, white fox pelts are poorer quality, and although saleable, bring reduced prices. The most valuable fox pelts are taken in January and February in the Barrow area.

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Table 11. Physical characters of Barrow white fox pelts, 1960-63

	Total length of pelt in cm [1]				Tail length in cm [2]		
	Year				Year		
Sex	1960-61	1961-62	1962-63	Ave.	1960-61	1961-62	Ave.
Male	109.0±1.0	104.9±2.5	75.7±1.3	97.3±.8	34.5±.4	35.6±2.5	34.5±.4
Number	26	2	15	43	26	2	28
Female	106.2± .8	109.2±3.6	70.6± .8	104.4±.7	33.8±.3	33.0±0	33.5±.3
Number	71	3	4	78	71	3	74

		Blacktipped tail			Blacktipped guard hairs		
		Sex			Sex		
		Male	Female	Total	Male	Female	Total
Present	Number	38	74	112	27	48	75
	Per cent	90.5	96.1	94.1	62.8	61.5	62.0
Absent	Number	4	3	7	16	30	46
	Per cent	9.5	3.9	5.9	37.2	38.5	38.0

Table 11. (Continued)

Ear color

Color		Male	Female	Total
White	Number	8	13	21
	Per cent	22.9	18.1	20.0
Gray	Number	27	59	86
	Per cent	77.1	81.9	80.0

Mystacial vibrissae color

Color		Male	Female	Total
White	Number	22	35	57
	Per cent	38.9	61.4	49.6
Black and White	Number	7	24	31
	Per cent	29.2	71.8	27.0
Black	Number	9	4	13
	Per cent	69.2	30.8	11.3
Brown and White	Number	1	7	8
	Per cent	12.5	87.5	7.0
Brown	Number	2	4	6
	Per cent	33.3	66.6	5.2

[1] Total length of pelt is measured from the tip of the nose on the head to the end of the longest hair on the tip of the tail.

[2] Tail total length is measured from the base of the tail to the end of the longest hair on its tip.

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REPRODUCTION AND BIOTIC POTENTIAL

White foxes are monestrous, monogamous, and perhaps mate for life (Seton 1929; Dement'yev 1955). Males mature at 10 months, having a minimal, functioning testes weight of 2.6 grams (Sokolov 1957). Spermatogenesis begins in January, and mature spermatozoa are found in the epididymis from March until the end of July (Asdell 1964; Sokolov 1957). Large follicles occur in the ovaries in February and March; corpora lutea are well-developed until the beginning of August (Asdell 1964).

Fox mating, indicated in the snow by sets of paired tracks, begins in March and early April on the Arctic Slope (Helmericks, correspondence), at the end of April or early May in Siberia (Sokolov 1957), and in March or April on Southhampton Island, Canada (Sutton and Hamilton 1932). Kokolov (1957) found no indication of oestrous from January until April 10.

After a gestation period of 52 days (Barabash-Nikiforov 1938; Johnson 1946), the annual litter is born in May, June, or early July. A high reproductive potential for this species is indicated by the data summarized in Table 12. Barrow Village trappers usually noted four to eight pups per white fox litter, but have seen as many as 12 in one family.

Braestrup (1941) indicates that a real difference in pup production

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Table 12. Reproductive potential of the white fox (Alopex lagopus)

NUMBER OF EMBRYOS

Literature source	Average number	Maximum number
Zhitkoff 1913		16
Schaaning 1916		16
Sutton and Hamilton 1932	11-12	16
Braestrup 1941		21
Gavin 1945	4.8	17, 23
Chirkova *et al.* 1959	6.5	

NUMBER OF PUPS IN THE LITTER

Literature source	Average number	Range
Gmelin 1760	6-8	1-25
Fabricus 1788	3-7	
Middendorff 1875	3-7	1-25
Muller 1906	6-8	1-10
Collet 1912	6-8	1-18
Judge (*in* Osgood *et al.* 1913)		5-11
Hartman 1929	4-12	
Seton 1929	4-5	1-11
Lavrov 1932	4-5	4-13
Høst 1935		1-21
Bachrach 1936	4-5	1-11
Dubrovskii 1937	5-7	1-16
Barabash-Nikiforov 1938	6-7	4-10
Braestrup 1941	6.4	
Soper 1944	4	
Gavin 1945	4-6	7-8
Dufresne 1946	10-14	
Cahalane 1947	6-7	1-12
Chirkova 1951-good year	8-10	
Chirkova 1951-poor year	4-5	
Hilderbrand 1952	4-8	10-21
Leekley (*in* Hilderbrand 1952)	6-8	1-15
Dement'yev 1955	8	5-15
Chirkova *et al.* 1959	4.5	

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between blue and white phases of the white fox exists in Greenland; with the white phase being more prolific. More study is needed on both the blue and white fox before this reproductive difference can either be denied or confirmed.

Braestrup (1941), Chirkova (1951), and Dement'yev (1955) have commented on the reduced production of fox pups during periods of food scarcity. Macpherson (1962) found that at Resolute Bay and the Central District of Keewatin, Northwest Territories, Canada, weaned litter counts varied directly with lemming numbers. The mean litter size in 1960 was 9.7 pups; in 1961, 4.6; and in 1962 zero; while associated midsummer lemming indices were 85, 57, and 13 respectively. Similar reproductive losses are well documented in other animals, especially in ungulate populations (Severinghaus and Cheatum 1956), and it appears reasonable to assume that similar mechanisms operate on white fox populations during food scarcity.

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POPULATION DYNAMICS

White fox fur harvest data from Alaska (Fig. 9) indicate that periodic peaks in the fox population occur approximately every 3.6 years, and population lows every 3.9 years. An average four year population cycle is well-established for white fox in Ungava and Labrador, Greenland, Novaya Zemlya, northern Quebec, and in the Northwest Territories, Canada (Elton 1942; Braestrup 1941; Dubrovskii 1937; Butler 1951; Chitty and Chitty 1945). But, while it is essentially the same duration, the Alaskan white fox cycle is not simultaneously in-phase within these regions.

These periodic increases in foxes are usually closely correlated with a similar population increase in the primary prey of the foxes, small rodents. In the Barrow area the fox highs in the past 20 years have usually coincided or followed right after brown lemming (*Lemmus trimucronatus*) population peaks (Rausch 1958; Pitelka *et al.* 1955; Thompson 1955). The southward migration of snowy owls (*Nyctea nyctea*) also coincides with the abrupt lemming decline, and usually indicates a high, if not peak, white fox population in the north (Gross 1931, 1947; Kirpichnikov 1937).

It is clear that the fox and lemming cycles are interrelated, but exact data on the mechanisms involved and governing these interactions are lacking. Diseases, parasites, predation, competition, migrations

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and seasonal movements all may play proportionate roles in these population fluctuations.

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MOVEMENTS AND MIGRATIONS

White fox movements may be classified into four general categories: local movements, the general, daily travels of an individual fox; sporadic movements, those involving the unpredictable occurrence of individual foxes many miles from their normal range; seasonal movements, those that are correlated with seasonal changes in the environment; and migrations, periodic movements involving many foxes traveling long distances in one sustained direction (McEwen 1951).

Seasonal Movements

On the Alaskan Arctic Slope, two distinct seasonal movements occur, with the first in the fall and early winter months when foxes move seaward towards the coast and sea ice; and the second in late winter and early spring months when they return inland to mate and occupy summer den sites. Similar seasonal movements have been noted in the Hudson and James Bay regions, on Southern Baffin Island, and on the Taymyr Peninsula (Soper 1944; Preble 1902; Seton 1929; Richardson 1829; Chitty and Chitty 1945; Alekseev 1957). The fall and winter movement is probably triggered by food scarcity (Barabash-Nikiforov 1938; Chitty and Elton 1937). Rausch (1958) found foxes often became abundant along the Arctic Coast during the fall and early winter following an abrupt lemming decline. White foxes were abundant

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in the Barrow coastal region in 1949, 1953, 1954, and 1956, the year of greatest concentration (Rausch 1958).

Instances of sporadic movements of Alaskan white foxes are indicated by distribution records from the Yukon Flats, Kenai Peninsula, Kodiak Island, Nushagak, and Togiak District (Appendix I). McEwen (1951) attributes his 40 records of this species occurring far south of their normal Canadian range to sporadic movements.

White foxes are capable of traveling long distances over sea ice and being carried by ice floes to many areas that they do not normally occupy (Bailey and Hendee 1926; Anderson 1946; Elton 1949; Banfield 1954; Cameron 1950; Lewis 1942). Foxes commonly immigrate to the Bering Sea Islands via the pack ice from the north (Preble and McAtee 1923; Murie 1936). Nansen saw fox tracks on polar ice 150 miles north of Franz Josef Land, and McClintock saw a blue fox, March, 1958, on the winter ice of Baffin Bay about 130 miles from Greenland (Elton 1949). Movement of Alaskan foxes on sea ice is discussed elsewhere (See Distribution, p. 7).

Migrations

White fox migrations, as described from other areas of the Arctic, have not been observed and recorded in Alaska. These reports of fox migrations note that the foxes follow the coastline southward, and it is expected that if such a marked movement involving many foxes occurred

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here it would either be recorded in the literature or at least known by local trappers. Neither has occurred. Definite fox migrations have been reported from Novaya Zemlya, the Yamal and Taymyr Peninsulas, Yenisey Tundra, and in northern Europe (Lavrov 1932; Vasil'ev 1938; Kalashnikov 1936; Chirkova 1951; Yakushkin 1963).

Chirkova (1955) states that the shortage of food is the historical trigger of the white fox migrations; and this view is supported by other Russian workers (Lavrov 1932; Kirpichnikov 1937; Dubrovskii 1937). Seton (1929) believes that the migration of white foxes consists only of young of the year, the surplus population that the range cannot support, and that this movement is truly emigration rather than migration since few of the young animals survive to return to their home areas. Recent data by Pullainen (1965) indicates that it is mainly male foxes that are involved in these migrations.

Migrating foxes are reported to follow caribou herds and to feed on caribou killed and left by wolves (Manning 1943). Other biologists have recorded foxes following caribou herds (Critchell-Bullock 1930; Dubrovskii 1937; Clarke 1940).

Care of Young and Pup Dispersal

Both the male and female white fox care for the young pups throughout the summer (Seton 1929; Barabash-Nikiforov 1938; Cahalane 1947). The pups are weaned when they appear outside the

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burrow (Dubrovskii 1937), and pup dispersal begins in late August through October when the family unit gradually breaks up and abandons the den site (Lavrov 1932; Dubrovskii 1937; Barabash-Nikiforov 1938; Shibanov 1951; Chirkova 1951).

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DEN ECOLOGY

During July and August 1962, 50 white fox dens were studied on the Teshekpuk Lake Section of the Alaskan Arctic Slope. Data on site topography, soil characteristics, permafrost depth, den construction, den density, and vegetative cover were collected.

Dens were located by intensive coverage of areas surrounding the camp sites (Fig. 1). Dens considered to be active were those having at least one of the following characters: tufts of white fox fur clinging to the entrance of the den; recent signs of digging or freshly dug entrances at the site; white fox tracks and well-worn fox trails entering the den area; and the presence of fresh white fox scats in the den area. Only den sites with positive white fox sign were studied, thus preventing confusion with red fox den areas. Few red fox occur here so confusion of fox species was a minor problem.

Aerial Search for Fox Dens

Using a Cessna 195, an aerial transect was flown June 24, 1962 to determine if white fox den sites could be located from the air. Clear, sunny weather during the flight provided excellent visibility for the three observers and the pilot. Throughout the flight, an average altitude of 30 to 50 m was maintained while airspeed varied between 160 and 200

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km per hour. Only six dens, two along the sandy banks of the Inaru River, and four in low mounds north of Teshekpuk Lake were seen on the entire flight. The fresh earth diggings of each den seen on the flight made it easily visible from the air; but the high speed of the aircraft and the uniform, drab coloration of the vegetation hampered aerial location of most den sites. Using aircraft of slower speeds later in the summer after plant growth has begun may permit the successful aerial location of den sites. During late summer, the lush vegetation surrounding fox dens (Figs. 8 and 9) made their location easy for ground observers and should make these sites more visible from the air.

Den Frequency and Occupancy

White fox dens were common over much of the area studied, but only two of 50 dens had signs of recent usage by fox pups. Skrobov (1961) reports that on the Yamal Tundra the percentage of occupied dens is a reliable indicator of the coming harvest. He notes 3% occupancy indicates a low trapping harvest, while 30% occupancy a moderate harvest during the next trapping season. Assuming these data apply to the Arctic Coastal Plain, a low white fox harvest could be expected during the 1962-63 trapping season. During this season the fox harvest was in fact low, but it can only be speculated whether this low harvest was due to a lack of white fox, the lack of trapping pressure, or a combination of these or other unknown factors.

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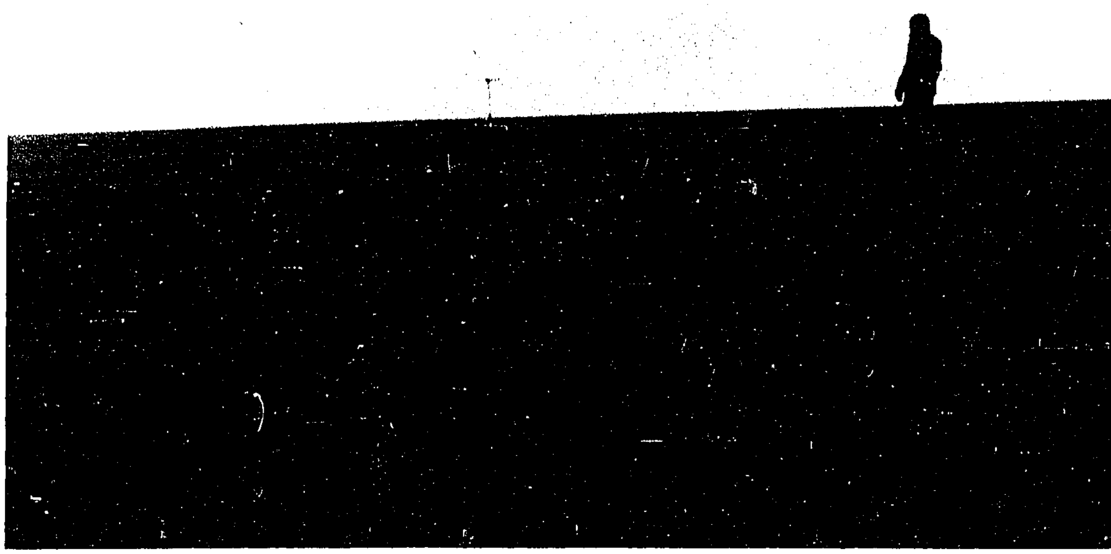

Fig. 8. Floristic pattern outlines white fox den site near Camp II. July 10, 1962.

Fig. 9. Typical fox den in low mound at Camp I. Well-worn main entrance is directly below soil thermometer. July 6, 1962.

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Den Site Topography

Almost all of the dens, 49 of the 50, were located in low mounds 1 to 4 m high (Fig. 4). Most of these dens were dug in the outermost row of mounds, but a few also occurred in the midst of other low mounds. A minimum mound height of 1 m appeared necessary for a white fox to successfully establish a den site. Many incomplete dens and no successful dens were found in mounds lower than 1 m. The shallow active layer and a wetter, heavier soil in the below-minimum height mounds prevents the establishment of suitable fox dens.

These low mounds consist of an ice core and are covered by either silts and sands or moss peat (Hussey and Michelson 1966). These small mounds, usually having a maximal relief of slightly more than a meter high and 3 to 4 m in diameter, occur in basinal marshes, on the initial surface residuals, and on the interconnecting slopes of the Arctic Coastal Plain. Geologists speculate that the most probable origin of these ice-cored mounds is the result of ice injected into horizontal contraction cracks. Soil mound ice cores have soil particles dispersed throughout the ice mass while peat mound ice cores are composed of alternate layers of soil and ice.

The location of the den site in relation to lakes and rivers on the tundra apparently varies with the locality. No direct relationship between den sites and water was noted in the Camp I and IV areas.

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Here, 19 of 20 dens examined were all located in low mounds at varying distances from water. Only two dens were dug at the edge of a small river, while two more dens were located in a group of low mounds completely surrounded by wet marsh. The only den not located directly in low mounds was dug in the crumbling bank of a lakeshore. Recent shoreline slumping had destroyed parts of this den.

Den locations around Camps II and III apparently are governed at least partially by the conditions created by stream erosion and soil deposition along streams (Fig. 10). Danilov (1958) noted this relationship between den sites and rivers on the Bol'shezemel'skaya Tundra. Dens were seen along the Inaru and Chipp Rivers; Geist (viva voce) noted a number of white fox dens in the sandy mounds and bluffs along the Meade River. Examination of the unstabilized dune areas along the Chipp River, 5 to 10 km from Camp II, revealed no white fox dens; the sand in this area appears too loose to support the construction of a tunnel system. All 13 dens located at Camp II were in the stabilized dune and low mound habitat located within 100 m of water (Figs. 10 and 11). Of these dens, 11 were along the banks of rivers and small streams, while two were dug on lakeshore banks. All five dens found near Camp III were located near existing lakes or where lakes had occurred at one time. These 13 den sites were all located in the same low mound-type of habitat occupied at Camps I and IV.

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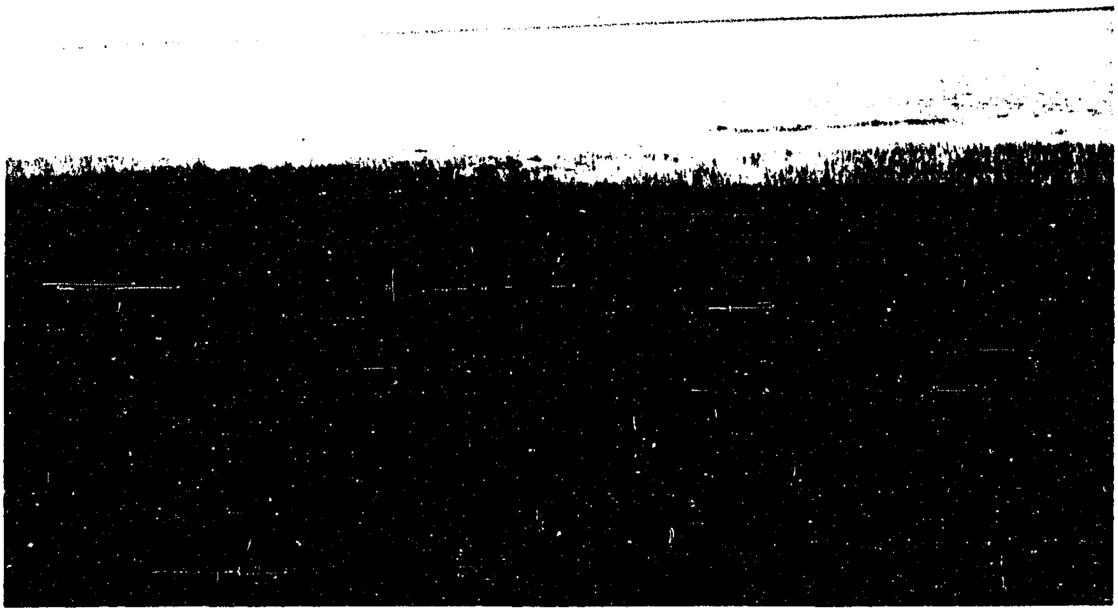

Fig. 10. White fox den site in sand mound at lake edge, Camp II. July 12, 1962. Salix sp. and Dryas integrifolia dominate vegetation at sandy den sites.

Fig. 11. Large fox den at edge of a tundra stream, Camp I. July 5, 1962. Fox usage and wind erosion create bare areas at den site.

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External Den Characteristics

Conspicuous groupings of white fox dens in the Camp I and IV areas, although all dens were not simultaneously active, show that at least here foxes will locate dens in a concentrated area with only a few meters separating them from neighboring den sites. At Camp I a group of nine dens was found within a 30 m section of low mound habitat, and another concentration of 13 dens all within 65 m of one another was located in a series of 2 to 4 m high mounds along the eastern shore of Tusikvoak Lake.

Each den entrance was approximately 187 mm (90-340 mm) in diameter. An average of four den entrances was found at each den site, but the largest den found during the summer, number 29, had 26 entrances, and an over-all area of more than 100 m^2. Dens were essentially circular in area, usually occupying less than 30 m^2 per den site. From the large size of several fox dens, it appears that they were used repeatedly year after year (Fig. 11).

Over 50% of the den entrances had a southerly or easterly exposure, while only 5% of the entrances had a northerly exposure. This may indicate a preference for location of den entrances on the warmer exposures.

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Den Site Soil Characteristics

Thirty-six den site soil samples and 13 soil samples from non-den habitats were analyzed by hydrometer analysis to determine sand, silt, and clay content. Lambe (1951) outlines the laboratory procedure and calculations used in determining this data. Laboratory work was done at the soils testing laboratory, University of Alaska, College, Alaska.

Soil samples were collected from several spots within the den site area with an aluminum soil sampling tube. Several vertical columns of soil, approximately 2.54 cm in diameter and 28 cm long, were removed from the ground and mixed together to provide the soil sample. Soil samples from non-den habitats were usually taken at random within a 100 m radius of the den sites, but in a different topographical type than that in which the den occurred.

The best criteria of soil texture at the den sites were per cent of sand and per cent of silt and clay in the samples (Fig. 12). The soil samples from Camps I, III, and IV were not different statistically from one another, so they were grouped to provide a larger sample(Table 14). But, as shown by Fig. 12, t-test calculations (Appendix IV), and conclusions reached during the summer field work, the soils at the white fox den sites at Camp II are sufficiently different from those from other areas to be treated as a separate unit. The alluvial origin of Camp II den site soils indicated this from the very beginning of the study. Only at Camp

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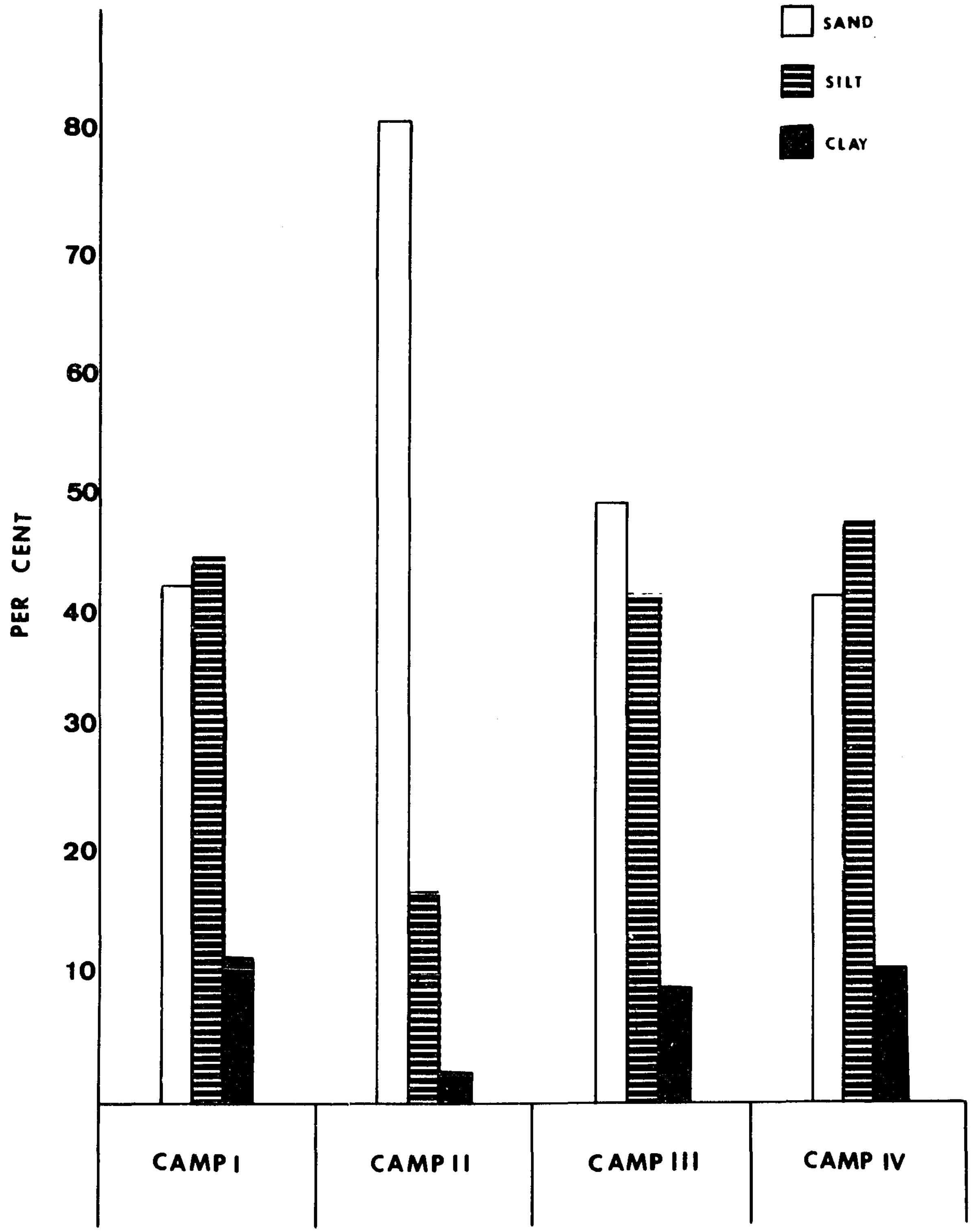

Fig. 12. White fox den site soils analysis: per cent sand, silt, and clay in soils from low mound denning areas.

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II does a measurable difference in soil texture between den site habitat and non-den habitat develop.

Based on this data (Table 13), it appears that Camp II fox dens are directly influenced by soil texture and are located in those areas having a very high sand content; but at Camps I, III, and IV little soil texture difference exists between den and non-den habitats.

Permafrost Depth

The depth to the permafrost surface below the ground's surface determines if a white fox can successfully den on the Teshekpuk Lake Section of the Alaskan Arctic Slope. At each den site a metal probe was used to determine permafrost depth in the approximate center of the den mound. Permafrost depths also were taken in another different habitat within a 100 m radius of the den site to determine if any conspicuous depth to permafrost difference existed between the two areas. These differences, very significant when tested at the 99% level with the t-test (Appendix V), indicate that the white fox den sites have deeper active layers than do the non-den areas (Fig. 13).

A direct relationship between mound height and depth to permafrost exists; the higher mounds usually having deeper depths to permafrost levels. The depth to permafrost is greater on the top of the mounds than along its base and sides; so consequently, more of the burrow system is located in the upper portion of the mound. Many unfinished

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Table 13. Comparison of sand, silt, and clay content of soils at white fox den sites and non-den habitats on the Teshekpuk Lake Section of the Arctic Slope, Alaska

Area	Size of sample	Sand	Silt	Clay	Sand & silt	Sand & clay	Silt & clay
		SOILS OF DEN HABITATS					
Camp I	7	42.5	44.3	11.9	87.9	55.8	57.5
Camp II	11	80.8	16.9	2.4	97.6	83.1	19.3
Camp III	5	49.3	41.3	9.5	90.5	58.7	50.7
Camp IV	12	41.6	47.3	11.1	88.9	52.7	58.4
Camps I, III, & IV	35	43.5	45.2	11.0	89.0	54.5	56.5
		SOILS OF NON-DEN HABITATS					
Camp I	12	47.4	43.1	9.5	90.5	62.1	52.6
Camp II	1	23.4	69.6	7.0	93.0	30.4	76.6
Camps I & II[1]		45.5	45.2	9.3	90.7	54.5	54.8

[1]Samples from III and IV areas lost in testing failure in soils laboratory.

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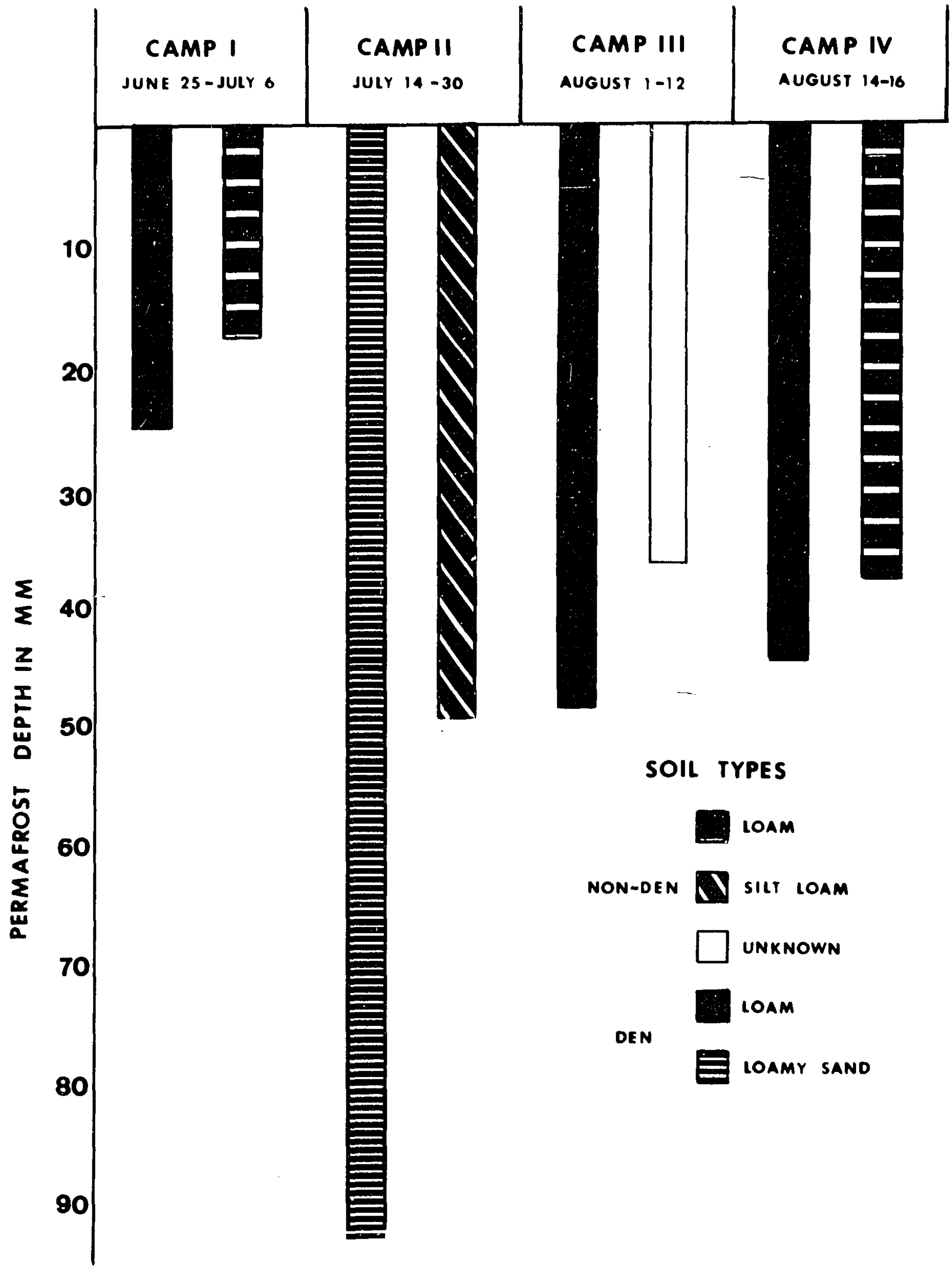

Fig. 13. Permafrost depths in den and non-den habitats, Teshekpuk Lake Section, Arctic Slope, Alaska.

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fox burrows, usually 14 to 18 cm deep, were found. These attempted burrows had been dug down to permafrost and then abandoned.

Den Site Soil Temperatures

At the beginning of the study of each den site, one soil thermometer was placed in the center of the den site and another within 100 m in another habitat type; after at least one hour the soil temperatures from both thermometers were simultaneously read and recorded (Fig. 14). An average soil temperature of 8.6 C was maintained at the 50 den sites, while 40 non-den habitats had an average soil temperature of 6.4 C. A significant difference, when tested with the t-test at the 99% confidence level, is indicated between the data from Camps I and II but not at Camps III and IV (Appendix VI). Generally, den site habitats had warmer soil temperatures than did non-den habitats.

Den Site Vegetation

A line-intercept method of sampling was used to obtain data on the vegetation type and species importance at the den mounds. Only mounds containing fox dens were studied in detail, although general notes on the flora in non-den areas were taken to provide the basis for general comparisons between habitats. At each den, one line-intercept was systematically located through the most active den entrance, with one end of the transect terminating at the outer area of den site influence, and the

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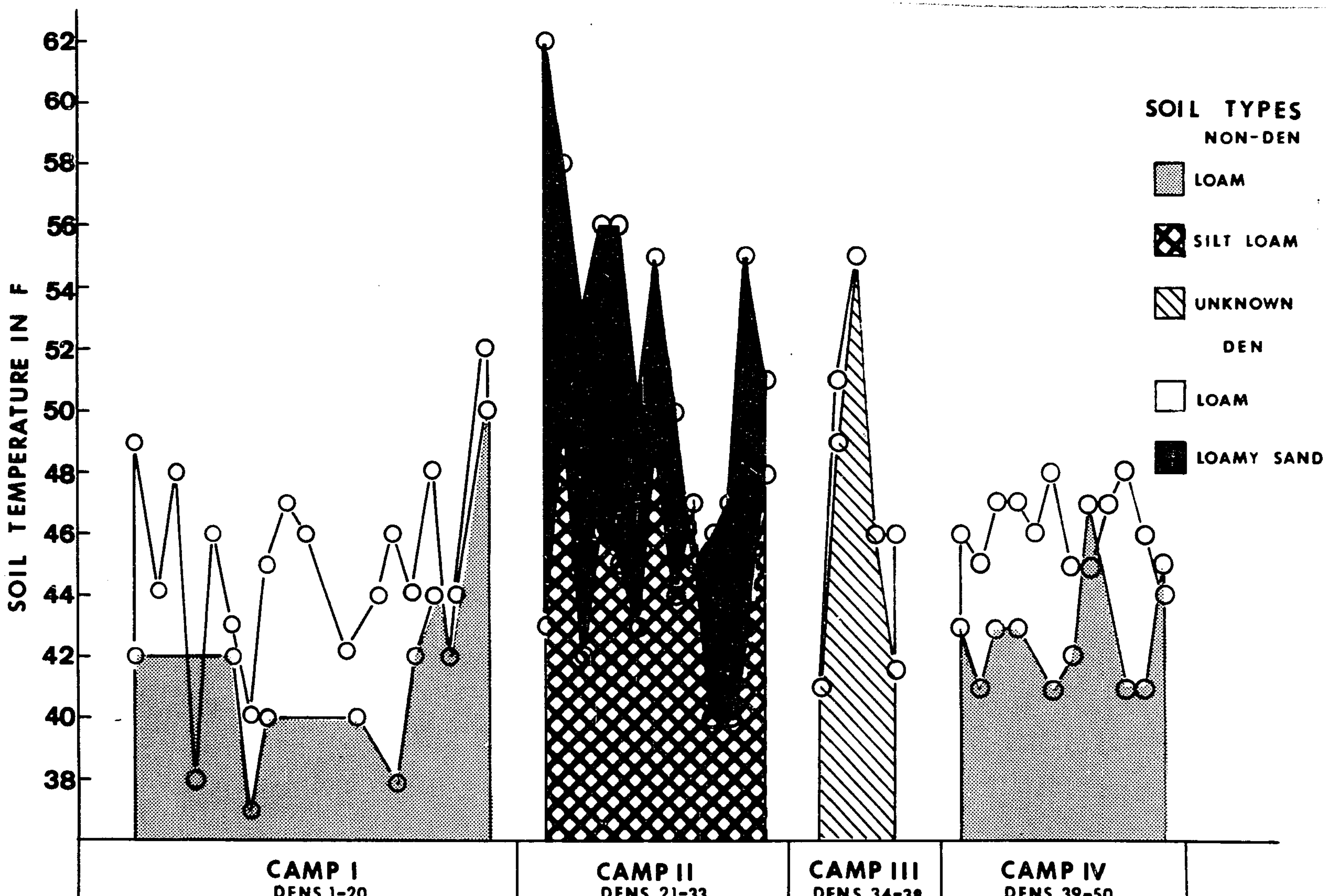
Fig. 14. Soil temperatures in den and non-den habitats, Teshekpuk Lake Section, Arctic Slope, Alaska.



other at the approximate center of the den site area. Transect length for an individual den site approximates the radius of each den area. All plants touching the transect line were tallied by species and area covered. Data on frequency of occurrence and species coverage are given in Table 14.

Living vegetation occupied 79.2% of the 14,386.6 cm total transect taken on the 50 den sites. Bare soil occupied 85% of the non-living section of the transect. Vascular plants occupied 86.7% (9,935.8 cm) of the vegetation on the transect; while mosses occupied 8% (915.7 cm); and lichens 5.1% (589.9 cm). Fungi and liverworts, primarily Marchantia polymorpha, occurred in very limited amounts at the den sites.

Hierochloe alpina, Alopecurus alpinus, Arctagrostis latifolia, Dryas integrifolia, Luzula confusa, Salix spp., and Saxifraga spp., dominate the vegetation of the den site. Wiggins and Thomas (1962) have also noted similar floristic situations around fox dens on the Arctic Slope.

The presence of the fox den on the tundra radically alters the plant community near the burrow, replacing the typical dry tundra community with a lush, vigorous one dominated by 30 to 50 cm high patches of Poaceae (Figs. 8 and 9). This den disturbance produces a lush, grassy cover that stood out in bold contrast to other vegetation growing beyond the influence of fox activity at the den site. Increased plant growth at den site areas is probably due to the addition of more organic materials to the soil, which in turn increases its fertility.

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Table 14. Distribution and abundance of vascular plants at white fox den sites, Teshekpuk Lake Section, Alaska

Species	Camp I		Camp II		Camp III		Camp IV		Total	
	F[1]	%[2]	F	%	F	%	F	%	F	%
Poaceae										
Alopecurus alpinus	8	9.4	4	25.7	-	-	-	-	12	14.0
Calamagrostis neglecta	1	T[3]	-	-	-	-	3	11.5	4	11.5
Hierochloe alpina	1	T	5	10.1	4	24.2	8	23.1	18	9.3
Arctagrostis latifolia	1	19.7	1	.9	-	-	-	-	2	8.0
Poa arctica	3	4.7	3	8.9	-	-	-	-	6	5.4
P. alpigena	-	-	-	-	3	2.5	-	-	3	2.5
unidentified grasses	15	15.8	-	-	-	-	1	T	16	6.2
	29	49.9	13	45.6	7	26.7	16	35.0	65	44.6
Salicaceae										
Salix spp.	9	11.5	4	5.6	6	21.9	2	13.3	21	10.5
S. pulchra	-	-	8	14.5	-	-	-	-	8	5.8
S. alaxensis	-	-	-	-	-	-	5	14.0	5	1.7
S. phlebophylla	5	3.8	-	-	-	-	-	-	5	1.5
S. reticulata	-	-	2	T	-	-	-	-	2	T
	14	15.2	14	20.1	6	21.9	7	27.3	41	19.7
Rosaceae										
Dryas integrifolia	-	-	10	20.4	4	14.7	-	-	14	9.5
Potentilla hyparctica	-	-	-	-	2	2.2	3	6.8	5	1.0
			10	20.4	6	16.9	3	6.8	19	10.5
Juncaceae										
Luzula confusa	14	15.8	-	-	1	2.2	6	10.5	21	7.7
	14	15.8			1	2.2	6	10.5	21	7.7

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Table 14. (Continued)

Species	Camp I F	Camp I %
Compositae		
Petasites frigidus	3	2.3
Taraxacum spp.	-	-
Erigeron humilis	-	-
Saussurea angustifolia	-	-
unidentified composite	-	-
	3	2.3
Saxifragaceae		
Saxifraga spp.	6	4.2
S. punctata	8	2.8
S. cernua	-	-
	14	7.0
Caryophyllaceae		
Arenaria rubella	-	-
Stellaria longipes	-	-
S. ciliatosepala	-	-
Cerastium beeringianum	-	-
Ericaceae		
Cassiope tetragona	6	2.6
	6	2.6
Papaveraceae		
Papaver spp.	2	.5
	2	.5
Polygonaceae		
Oxyria digyna	4	3.3
	4	3.3

Camp II		Camp III		Camp IV		Total	
F	%	F	%	F	%	F	%
1	T	2	3.0	2	6.6	8	2.0
2	3.0	-	-	-	-	2	1.2
1	1.6	2	5.7	-	-	3	1.2
1	T	1	1.6	-	-	2	T
-	-	-	-	2	T	2	T
4	4.6	5	10.3	4	6.6	17	4.7
-	-	-	-	-	-	6	1.6
-	-	-	-	1	T	9	1.2
-	-	-	-	1	1.0	1	T
				2	1.0	16	2.9
3	3.9	-	-	-	-	3	1.6
-	-	4	8.7	-	-	4	.8
3	T	-	-	-	-	3	T
-	-	-	-	2	T	2	T
6	3.9	4	8.7	2	T	12	2.5
-	-	2	4.4	2	2.1	10	1.7
		2	4.4	2	2.1	10	1.7
4	2.3	2	6.0	-	-	8	1.7
4	2.3	2	6.0			8	1.7
-	-	1	1.6	-	-	5	1.4
		1	1.6			5	1.4

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Table 14. (Continued)

Species	Camp I F	Camp I %	Camp II F	Camp II %	Camp III F	Camp III %	Camp IV F	Camp IV %	Total F	Total %
Cyperaceae										
Carex spp.	2	1.2	-	-	-	-	-	-	2	.5
C. lugens	-	-	-	-	1	.8	-	-	1	T
Eriophorum vaginatum	1	1.2	-	-	-	-	-	-	1	.5
unidentified sedge	-	-	1	1.0	-	-	-	-	1	T
	3	2.4	1	1.0	1	.8			5	1.4
Vacciniaceae										
Vaccinium vitis-idaea	3	.6	-	-	-	-	2	2.1	5	.5
	3	.6					2	2.1	5	.5
Ranunculaceae										
Ranunculus sulphureus	1	T	-	-	-	-	-	-	1	T
R. pedatifidus	-	-	1	.5	-	-	-	-	1	T
R. spp.	1	T	-	-	-	-	-	-	1	T
	2	T	1	.5					3	T
Cruciferae										
Cochlearia officinalis	1	T	-	-	-	-	-	-	1	T
Draba cinerea	-	-	1	T	-	-	-	-	1	T
unidentified mustard	-	-	1	T	-	-	-	-	1	T
	1	T	2	T					3	T

[1] Frequency of occurrence; the number of times plant occurred in total number of transects taken at the den sites.

[2] Per cent of area occupied by the species along the line transect.

[3] Per cent of occurrence less than .5%.

FOOD HABITS

White fox food habits reflect the seasonal distribution and abundance of prey species within the fox's habitat. Distinct regional differences in the summer diet of inland and island fox and in the winter diet of inland and sea ice foxes exist. The periodic population fluctuations of prey species, primarily in the microtine populations, also must alter fox food habits markedly.

These data on food habits were collected on the Teshekpuk Lake Section of the Arctic Slope, Alaska, from November, 1961 until March, 1963. The summer food data describe the diet of inland or tundra foxes while the winter food material reflects that of foxes living along the coast on the edge of the sea ice (Figs. 15 and 16).

Microtines, mainly brown and collared lemmings (Dicrostonyx groenlandicus), are the primary white fox prey throughout the year. Whenever available during the year sea mammals and caribou are also eaten.

Birds and bird eggs form an important part of the summer diet of foxes but show a marked decrease in usage during the winter months. This decrease in winter utilization coincides with the seasonal decrease of avain availability on the Arctic Slope.

Ground squirrels (Spermophilus undulatus), fish, insects, and

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Fig. 15. Snow and ice pressure ridges: winter habitat of white foxes living on sea ice near Point Barrow, Alaska. March 21, 1963. The snow ridges in the foreground are approximately 1 m high; the pressure ridge in the background 2 to 3 m high.

Fig. 16. Inland tundra winter habitat of white foxes near Point Barrow, Alaska. March 21, 1963.

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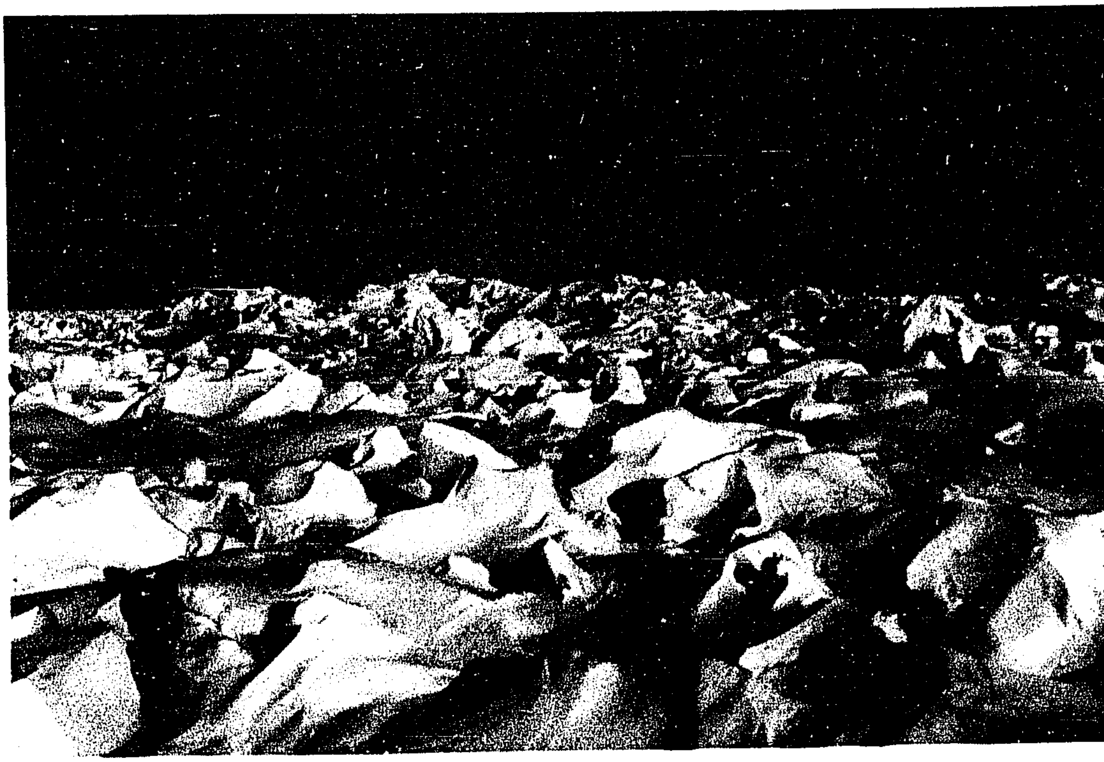

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snails are eaten during the summer but were absent from the winter diet. During the winter the occurrence of non-food items, such as rags and paper, increases sharply, indicating a corresponding seasonal shortage of suitable fox food.

Summer Food Habits

Lemmings are the major fox prey during the summer months (Tables 15 and 16). Many studies have noted the importance of lemmings in fox diets (Braestrup 1941; Elton 1942; Pitelka *et al.* 1955; Macpherson 1962).

Birds and eggs also form a large part of the fox summer diet. Foxes prey heavily on nesting birds and are extremely efficient predators, often governing the nest location of sea-bird colonies (Turner 1886; Nelson 1887; Manniche 1912; Osgood *et al.* 1913; Lavrov 1932; Dubrovskii 1937; Kirpichnikov 1937; Bertram and Lack 1938; Braestrup 1941; McEwen 1958; Fay and Cade 1959). Ptarmigan (*Lagopus* spp.) are also eaten by foxes during the summer (Gross 1931; Barabash-Nikiforov 1938; Gunderson *et al.* 1955).

Other summer food items in the fox diet include fish, caribou, sea mammals, insects, berries, grasses and various herbaceous plants (Osgood *et al.* 1913; Freuchen 1935; Barabash-Nikiforov 1938; Braestrup 1941). Lavrov (1932) found that marine invertebrates were an important part of the summer diet of island foxes.

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Table 15. Comparison of 200 summer and 39 winter white fox scats collected on the Teshekpuk Lake Section, Arctic Slope, Alaska, from June, 1962 until March, 1963

Food items	Frequency of occurrence: Summer Number	Summer Per cent	Winter Number	Winter Per cent
Mammals (total)	197	98.5	38	97.4
small mammals (total)	189	94.5	35	89.7
brown lemming	170	85.0	34	87.2
collared lemming	6	3.0	--	----
unidentified small mammals	23	11.5	--	----
caribou	30	15.0	2	5.1
sea mammals	2	1.0	3	7.8
Birds (total)	117	58.5	10	25.6
eggs	72	36.0	3	7.7
feathers and bones	78	39.0	7	17.9
Fish	3	1.5	--	----
Insects	15	7.5	--	----
Snails	2	1.0	--	----
Non-food items (total)	6	3.0	7	17.9
dirt (white powder)	4	2.0	--	----
white fox hair	2	1.0	--	----
cloth	2	1.0	2	5.1
leather shoe	---	----	1	2.6
rubber bits	---	----	4	10.3

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Table 16. Food remains recovered from 34 white fox den sites on the Teshekpuk Lake Section of the Arctic Slope, Alaska, during the summer of 1962

Food items	Frequency of occurrence	
	Number	Per cent
Mammals (total)	33	97.1
small mammals	33	97.1
brown lemming	32	94.1
collared lemming	9	26.5
unidentified small mammals	1	2.9
caribou	5	14.7
ground squirrel	3	8.8
unidentified large mammal bone	1	2.9
Birds (total)	22	64.7
feathers	17	50.0
egg shells	12	35.3
medium to large bird bones	19	55.9
small bird bones	9	26.5
shorebird skull	1	2.9
Insects	2	5.9
Fish	1	2.9
Non-food items	1	2.9
burlap rag	1	2.9

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Many reports of adult white foxes caching food for winter use exist in the literature (Feilden 1877; Beddard 1902; Osgood et al. 1913; Seton 1929; Freuchen 1935; Dubrovskii 1937; Braestrup 1941; Soper 1944). No evidence of this caching was found during the field work in the study area.

Winter Food Habits

The white fox winter diet depends primarily upon the habitat in which it spends the winter season. Food secured by foxes on sea ice is restricted to marine mammals and invertebrates, resident sea birds, sea weeds and algae, and marine fishes (Manniche 1912; Osgood et al. 1913; Lavrov 1932; Muller 1906 in Braestrup 1941; Barabash-Nikiforov 1938; Wanhoffen 1897 in Braestrup 1941; Dubrovskii 1937; Fabricius 1780 in Braestrup 1941).

White foxes may follow polar bears on the sea ice to feed on the remains of bear kills (Soper 1928; Freuchen 1935; Dufresne 1946; Cahalane 1947; Bee and Hall 1956). Foxes certainly could benefit from such behavior, and their ability to locate meagre food items under harsh conditions would help locate bear kills or any other available food on the sea ice.

During this study, white foxes commonly fed on gulls, sea ducks, and marine mammal carcasses washed ashore or frozen into the sea ice. Approximately 40 white foxes were located feeding on a dead walrus frozen into the sea ice off of Tangent Point, Alaska, December 5, 1961.

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The foxes had dug through .6 m of ice to reach the carcass, chewed a 30 cm diameter hole through the thick walrus hide; and were feeding inside the carcass. Schiller (1954) found white foxes on St. Lawrence Island, Alaska, feeding on dead walruses in the same manner.

Inland or tundra fox diets consist mainly of lemmings. This lemming diet may be supplemented by other microtines, caribou, arctic hare (Lepus othus), and ptarmigan (Soper 1928; Freuchen 1935; Pedersen 1926). Foxes have followed reindeer herds and attacked weak fawns (Blanchet 1925; Porsild 1945), and Manning (1943) believes that foxes may follow caribou herds to feed on wolf-kills.

Scat Analysis

Scats were collected at den sites and winter feeding areas to provide data on food habits. A scat was considered to be either the whole or any portion of an excrement defecated by any white fox. Scats showed considerable variation, but a general idea of animal age and scat content was indicated by its size, structure, and coloration.

Scats collected at the den sites were of unknown age; but because the dens usually are occupied from mid-April until late September or early October these scat contents were assumed to represent late spring, summer, and early fall fox foods. Den scats were of two types: (1) a large scat, averaging 15 mm in diameter at its thickest part, which was usually covered with a grey or whitish coat; and (2) a shorter, narrower

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scat, averaging 11 mm in diameter which was dark black. The latter were probably pup scats while the former represent those from adult fox.

Winter scats resembled the darker pup scats but were longer, more twisted and segmented, and thicker. All the adult scats had considerable twisting and segmentation which was lacking in pup scats.

Scat coloration reflects chronological age as well as scat content. Lighter scats more often contained bird remains and egg shells while the dark scats had either small mammal hair, partially digested meat, or both. Summer scats dry and become lighter with exposure while winter scats freeze and retain their darker hues.

I believe the winter scat analysis does not accurately reflect the true importance of sea mammals in the winter diet. Only 3 of 35 scats collected at Tangent Point, where foxes had gathered to feed on a dead walrus, contained identifiable sea mammal remains.

Traces of vegetation occurred in almost all summer and many winter scats, but probably this vegetation was ingested accidently with other food. Two per cent of the summer scats contained solid segments of soil, perhaps indicating more than accidental consumption. Soil has been noted in red fox scats (Baranovskaya and Kalosov 1935; Lund 1962). The absence of shrews (*Sorex* spp.) from the fox scats and den food remains may indicate that, as in the red fox and some of the mustelids, shrews may be killed but not eaten.

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PARASITES

Although abundant literature (Table 17) on the parasite fauna of the white fox has been published for other arctic and subarctic areas, information is limited from northern and western Alaska. In this study, 24 white foxes from the Barrow area were examined to determine their parasitic fauna.

Methods and Techniques

Specimens were either collected during field work or purchased from Eskimo trappers in the immediate Barrow area during the 1961-62 trapping season. These carcasses were frozen until examined.

When examined, all fox carcasses had been frozen and thawed at least twice since collection. This action damaged both carcass tissues and some of the parasites contained in the animal and made a thorough examination difficult. Detailed search for parasites was restricted to the fox's intestine, stomach, trachea, bronchi, diaphragm, and urinary bladder. Parasites were found only in the large and small intestines, diaphragm, and stomach.

All carcass examination was essentially macroscopic. Diaphragm tissue was dissolved with artificial digestive juice to reveal the presence of *Trichinella spiralis*. All parasites initially were placed in 10% formalin and later transferred to

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Table 17. Known parasites of the white fox that were NOT found in the 24 white foxes autopsied from Barrow Village, Alaska

Parasite	Authority
Cestoda	
Taenia pisiformis	Dubrovskii 1937; Dubnitskii 1953; Lavrov 1932; Thomas and Babero 1956
Dipylidium caninum	Dubrovskii 1937; Lavrov 1932
Diphylobothrium latum	Lavrov 1932; Rausch 1953
D. erinacei-europaei	Dubinina 1951
Nematoda	
Uncinaria stenocephala	Dubnitskii 1956; Lavrov 1932; Parnell 1934; Dubrovskii 1937; Thomas and Babero 1956; Olson 1958
Eucoleus aerophilus	Lavrov 1932
Toxascaris canis	Lavrov 1932; Kirpichnikov 1937
Spirocerca lupi	Luzhkov 1960
Strongyloides vulpis	Petrov and Dubnitskii 1946
Trematoda	
Opistohorchis felineus	Lavrov 1932; Luzhkov 1961
Microphallus pirium	Schiller 1959
Bacteria	
Listeria monocytogenes	Cromwell, Sweede, and Camp 1939; Nordland 1955
Ectoparasites	
Linognathus setosus	Ferris and Nuttall 1918 Lavrov 1932; Critchell-Bullock 1930; Sutton and Hamilton 1932
Siphonaptera	Ferris and Nuttall 1918
Anoplura	Lavrov 1932

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a 70% alcohol solution. All parasites were stored in alcohol until stained and mounted with standard microtechniques. Identification of parasite material was facilitated by reference to the existing literature and known specimens from the Arctic Health Research Laboratory, Anchorage, Alaska.

Results

Parasites were found in 88% (21 of 24) of the foxes. Only cestodes were found in 52% of the foxes while 8% had only nematodes. Both cestodes and nematodes were found in 17% of the examined animals.

Cestodes found in the intestinal tract and stomach of the white fox were: *Taenia crassiceps*, *T. polyacantha*, and *Echinococcus multilocularis*. Nematodes, *Toxascaris leonina*, found in the intestinal tract and stomach, and *Trichinella spiralis*, located in the diaphragm tissue, completed the list of parasites found in the fox examination.

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DISEASES

Rabies was recorded in white foxes from the Barrow area during the high fox populations of 1949-50, 1954, and 1956-57, but also was reported from other areas in years of population lows (Rausch 1958). Between 1949 and 1957, 19 rabid white foxes were reported from northwestern Alaska and St. Lawrence Island. Most rabies cases in foxes occur during the cold months of the year, but their source of infection is totally unknown. Elton (1931) has speculated on a relationship between a rabies-like disease in lemmings, which if assumed to exist during lemming die-offs, could be transmitted to this species. He gives little serious consideration to his theory, lacking any laboratory proof of such a disease in lemmings.

Rabies could be an important factor in fox mortality. During 1953-54, a rabies outbreak occurred among white foxes on St. Lawrence Island, Alaska. It was more extensive than the Barrow rabies outbreak of 1956-57, and possibly caused a significant reduction in its numbers on St. Lawrence Island. Freuchen (1935) regarded rabies as an important cause in the population decline of white foxes in eastern Canada.

Rabies in this species has also been reported from the western Canadian Arctic, Greenland, Novaya Zemlya, and Siberia (Braestrup 1941; Elton 1931, 1942; Lavrov 1932; Plummer 1947a, 1947b). In addition

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to rabies, Lavrov (1932) found white foxes infected with encephalitis, paratyphoid fever, and coccidosis. Chirkova (1953) reports tularemia among white foxes in the Voronezh Province.

Considerable literature is devoted to "sledge-dog disease" in the Arctic. Elton (1931) wrote that he felt this disease, affecting the central nervous system in dogs and white foxes, was neither ordinary rabies nor dog distemper. Recent research by Kantorovich (1956) noted similarities between an etiologic agent isolated from the white fox and the rabies virus; and after study, he has decided this agent is a variety of rabies virus (Kantorovich 1957). Between 1958 and 1960, Strogov (1961) found 6 out of 94 white foxes infected with this rabies variant. This variant may be identical to the sledge-dog disease of Elton and relatively widespread in the Arctic. Cowan (1949) suggests the 1949 decline of white foxes in the Mackenzie District, Canada, may have been caused by an epidemic resembling rabies. Autopsies of wolves and dogs attacked by infected animals showed positive evidences of rabies.

Chirkova (1951) noted the relationship between the lack of food, fox migrations, and the start of fox epizootics in her studies. No such clear cause and effect relationship between fox food, migrations, and epizootics can be defined for North American white fox populations at this time.

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COMPETITORS AND PREDATORS

Barrow trappers list red foxes, wolves, wolverines, and polar bears as the primary white fox predators; dogs (*Canis familiaris*) also may kill white foxes (Seton 1929; Lavrov 1932). Manniche (1912) found a fox killed by a polar bear in Greenland. Soper (1928) considers the red fox the most agressive white fox predator, but the fox trapper may deserve this title.

Skrovov (1960) notes the general northward advance of the red fox; and its replacement of the white fox wherever their two ranges overlap. Marsh (1938) reports a similar occurrence at Eskimo Point, 160 miles north of Churchill, Manitoba. There, Eskimos now find the red fox occupying white fox dens on the tundra. Dubrovskii (1937) also noted red fox occupancy of white fox den sites. Mullen (*viva voce*) witnessed an encounter between a white and red fox near Barrow, Alaska, but he saw no interspecific hostility between the two foxes.

Avian predators probably include snowy owls, large hawks, and jaegers. Sutton (1932) saw a white fox killed by an owl, and Bee and Hall (1956) found a white fox radius and ulna in a snowy owl pellet at a den site near Teshekpuk Lake. Both parasitic and long-tailed jaegers (*Stercorius parasiticus* and *S. longicaudus*) have attacked white fox pups (Collett and Nansen 1900; Birulya 1907). Foster (1955) considers rough-legged hawks

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(*Buteo lagopus*) a main enemy of foxes. Avian predation on the white fox is probably most prevalent on fox pups at den sites, but recorded instances of these interactions are lacking.

Some intraspecific strife between white foxes may occur. During periods of food scarcity or stress, white foxes may be cannibalistic (Lavrov 1932; Dubrovskii 1937). Adult foxes may kill and feed on other adults (Osgood *et al.* 1913) or pups (Lembley and Lucas 1902; Pedersen 1934). Devold (1940) has found young foxes feeding on their litter-mates.

Klein (*viva voce*) saw a white fox on St. Matthew Island, Alaska, drive other white foxes away from reindeer carcasses they were feeding on. There was never more than one fox at a carcass at a time. Also, white foxes were antagonistic toward others in the area when attempting to feed from a garbage pit near Klein's camp on St. Matthew Island.

The concentration of den sites found during the summer of 1962 at Camps I and IV indicates little intraspecific conflict may occur between white foxes in den areas, but Freuchen (1935) reports he saw a white fox actively defending a territory during the summer, driving away all strange foxes.

Interspecific competition between white foxes and other animals probably is most common in competition for food. Avian predators, primarily snowy owls and pomerine jaeger, and the least weasel (*Mustela rixosa*) all compete with the white fox at Barrow for lemmings

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(Pitelka *et al*. 1955). Also, wolves, red foxes, wolverines, and dogs actively compete for food, especially during the winter when food is scarce. During July, 1966, on St. Matthew Island, Alaska, Klein (*viva voce*) saw a red fox drive away a white fox that approached a reindeer carcass upon which it was feeding.

Instead of competing with white foxes, polar bears may augment the meagre fox food on the sea ice with the remains of their kills.

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Appendix I. Distribution records for the white fox in Alaska

Arctic Slope

No.	Location	Source
1.	Point Barrow and the immediate area surrounding it	Merriam 1900; Bee and Hall 1956; Miller 1912; Ray 1885; Nelson 1887; Stone 1900; Bailey and Hendee 1926; Hall 1929; Brower 1942; Dufresne 1946; Rausch 1953b; Geist *viva voce*; University of Alaska 4469[1]; Personal Observation
2.	Cape Simpson 71°00'N, 154°35'W	Bee and Hall 1956
3.	Tangent Point 71°8'13"N, 155°6'44"W	Personal Observation
4.	Half-Moon-Three 70°46'36"N, 155°19'11"W	Davies *viva voce*; Personal Observation
5.	Lake Tusikvoak 71°3'16"N, 156°22'33"W	Davies *viva voce*; Personal Observation
6.	Pitt Point	Bee and Hall 1956
7.	Cape Halkett	Alaska Game Commission 1936
8.	Arctic Coasts and along the Bering Sea Coast	Evermann 1913
9.	Northeast end of Teshekpuk Lake 70°39'40"N, 153°05'40"W	Bee and Hall 1956
10.	East end of Teshekpuk Lake 70°33'29"N, 152°37'40"W	Davies *viva voce*; Personal Observation
11.	Topagaruk River 70°34'N, 155°48'W	Bee and Hall 1956

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12.	Arctic Slope	Burt and Grossenheider 1952; Turner 1886; Richardson 1839; Harlan 1825
13.	Colville River Delta 70°05'N	Helmericks Communication
14.	Colville River 151°24'W	Bee and Hall 1956
15.	Mouth of Anaktuvuk River	Reed 1956
16.	Meade River	Ray 1885; Kelly _viva voce_; Geist _viva voce_; University of Alaska 4669[1]
17.	Between Point Barrow and 141st Meridian	Leffingwell 1919
18.	Barter Island	Strecker, Ryser, Tietz, and Morrison 1952; Barkalow 1952
19.	Demarcation Point	Bailey and Hendee 1926
20.	Area north of the Endicott Mountains	Alaska Game Commission 1931
21.	North of the mountains near Chandler Lake	Rausch 1951
22.	Killik River	Rausch 1951
23.	Itikmalukpuk Creek, northeast of Anaktuvuk Pass	Rausch 1953b
24.	Agiagiak (Easter Creek)	Rausch 1950a
25.	April Creek	Rausch 1951
26.	Bear Skull Cliff, 35 miles southwest of Barrow, Alaska	Bee and Hall 1956
27.	Wainwright, Alaska	Rausch 1953b

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28.	Point Hope	Alaska Game Commission 1929
29.	Icy Cape	Bailey and Hendee 1926
30.	Fish Creek Camp, 70°18'40"N, 152°N	Bee and Hall 1956
31.	Kaolak, 69°56'00"N, 160°14'51"W	Bee and Hall 1956
32.	Near the hill Nuasuknan. . . close to the upper Meade River	Murdock in Ray 1885; Nelson and True in Nelson 1887
33.	Upper Meade River	Nelson and True in Nelson 1887
34.	One mile south and .5 mile west of Umiat, Alaska	Bee and Hall 1956
35.	Near Cape Beaufort	Bailey and Hendee 1926
36.	Northern Alaska	Miller 1912, 1924; Anthony 1928
37.	Driftwood, Utukok River, 161°12'10"W, 68°53'47"N	Bee and Hall 1956
38.	Ivashak River, 68°51'12"N, 146°39'15"W	Bee and Hall 1956

Southcentral and Western Alaska

39.	Nushagak	Osgood 1904
40.	Togiak District	Osgood 1904
41.	Igagik	Osgood 1904
42.	Kenai Peninsula	Seton 1929
43.	Kuskokwim River Area	Dufresne 1946; Petroff 1898
44.	Seward Peninsula	Burns, Personal Communication; Alaska Game Commission 1928

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45.	Shismaref	Alaska Game Commission 1934
46.	Selawik	Alaska Game Commission 1936
47.	Kobuk	Alaska Game Commission 1936
48.	Kotzebue Region	Scott 1951; University of Alaska 5206[1]
49.	Ogotoruk Creek, 68°15'N, 166°W	University of Alaska 5091[1]
50.	Kissimilouk Creek, 68°05'N, 165°30'W	University of Alaska 5067[1]
51.	Noatak Village Area	Woolford 1954
52.	Kodiak Island	Seton 1929

Islands of the Bering Sea Region

53.	Diomede Island	Petroff 1898; Burns, Personal Communication
54.	St. Matthew Island	Hanna 1919; University of Alaska 3499, 3500[1]
55.	Pribilof Islands	Petroff 1898; Preble and McAtee 1923; Evermann 1913; Alaska Game Commission 1942
56.	Aleutian Islands	Alaska Game Commission 1942
57.	Nunivak Island	Alaska Game Commission 1932
58.	St. Lawrence Island	Rausch 1953a; Fay _viva voce_; University of Alaska 2074 2075-78, 2080, and 2083[1]; Murie 1936
59.	King Island	Burns, Personal Communication

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<u>Interior Alaska</u>

60.	Owens Cabin, Yukon Flats	Owens *viva voce*
61.	Sheenjek Valley	Anon. 1962
62.	Henshaw Creek, 10 miles south of Bettles around 1910	Rausch 1951
63.	Six miles up the valley of the East Chandalar River, above Arctic Village	Rausch 1953b
64.	Yukon Flats	Koontz 1963; Dice 1921

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[1] Specimen in University of Alaska biological collections.

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Appendix II. Harvest of white foxes in Alaska (1912-1963)[1]

Year	Numbers	Average $ value of pelt	Total harvest value
1912	3,108	12.50	$ 38,850
1913	3,756	12.93	48,565
1914	6,530	12.93	84,433
1915	5,967	13.00	77,571
1916	6,178	20.00	123,560
1917	3,682	28.00	103,096
1918	4,531	40.00	181,240
1919	4,575	46.00	210,450
1920	4,943	35.00	173,005
1921	2,108	30.00	63,240
1922	4,393	40.00	175,720
1923	7,080	42.02	297,476
1924	5,743	40.00	229,750
1925	16,658	35.00	583,089
1926	8,489	36.00	305,604
1927	2,849	40.80	126,184
1928	4,548	45.50	206,944
1929	12,188	60.25	734,341
1930	4,880	42.85	219,152

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1931	5,642	27.00	152,438
1932	6,207	17.18	106,606
1933	6,359	24.94	158,589
1934	4,313	20.35	97,756
1935	6,848	20.10	137,567
1936	5,117	19.50	99,727
1937	4,912	21.50	105,484
1938	3,519	17.00	59,823
1939	4,198	13.00	54,574
1940	4,634	11.25	62,505
1941	6,515	23.00	149,845
1942	2,154	25.00	53,850
1943	4,800	28.00	134,400
1944	4,552	30.00	136,560
1945	3,652	28.00	102,256
1946	1,364	30.00	40,920
1947	1,173	18.00	21,114
1948	1,384	18.00	24,912
1949	2,220	18.00	39,960
1950	2,660	17.00	45,220
1951	700	14.50	10,150
1952	1,200	14.00	16,800

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1953	2,000	12.00	24,000
1954	2,848	13.00	37,024
1955	800	13.00	10,400
1956	460	14.00	6,440
1957	500	16.00	8,000
1958	593	17.00	10,081
1959	1,850	17.00	31,450
1960	2,073	21.00	43,533
1961	2,100	17.00	35,700
1962	776	17.00	13,192
1963	1,395	12.50	17,437
Total	211,724		$6,030,583

Average 4,072 pelts taken per year, 1912-63.

Average value per pelt of $24.18 per year, 1912-63.

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[1]Data from files of Alaska Department of Fish and Game, Subport Building, Juneau, Alaska.

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Appendix III. Fox trapping techniques of the Barrow Village Eskimo

Some foxes are shot, but most white foxes are taken with number 1-1/2 or 2 longspring steel traps. Snares, deadfalls, and pit-traps were all used before 1900 to capture white foxes, but now these have been replaced by steel traps which are set on sea ice or on land.

On ice the trap is buried about 3 cm below the surface, and covered with white tissue paper or a sheet of crystaline snow. The snow cover is scraped to a thin sheet, 60 mm thick or less, before being laid over the trap depression. Care is taken to place the trap so that drifting snow will not clog its mechanism. Bait, usually sea mammal meat, is placed near the trap pan but windward to the trap, favoring the prevailing east-west wind. The bait is partially covered with a heavy block of ice which forces the fox to feed at the bait's exposed edge, near the trap pan. Care is taken to prevent the dark trap from showing through the opaque snow cover, and warning the fox. The trap is secured by burying a 90 cm stick, threaded through the trap chain, in a narrow trench cut in the ice which is packed with snow and eventually freezes. A trap marker, placed several yards from the trap, completes the set. Ice sets are very effective in March when placed along open leads, which foxes usually follow when searching for food.

The bait set on land is similar to the ice set. The trap is secured

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by a 90 cm stick buried in the frozen ground, or by a long metal spike driven into the frozen soil. After being buried slightly below the snow's surface, the trap is covered with snow or tissue paper as in the ice set. Large soil lumps are scraped away from the trap, and fine soil and snow is spread uniformly over the trap site, effectively hiding its location. Any available meat (although marine mammal meat is not usually used inland) is used as bait for land sets. The bait is placed approximately 36 cm from the trap on its windward side. Often, to attract the foxes attention, a large clod of soil is turned over near the trap. A trap marker completes the set.

The scent-post set is basically the same as the bait set, except that an upright stick or caribou antler replaces the bait. Commercial or home-made scents may or may not be sprinkled on the set and post. Several traps may be set around the scent post, near its base, increasing the chances of catching any white fox that visits it.

A combination scent-post-bait set has the initial scent-post set plus bait located a few feet from the scent post. No traps are set at the bait. After foxes have fed on the bait, they approach the scent-post to leave sign, and are trapped.

Trapped foxes are usually suffocated by the Eskimo trapper. The trapper stands on the animal's chest, collapsing the lungs, and death occurs within a few minutes. This method leaves no blood stains on the

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white pelt.

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Appendix IV. T-test calculations for soil texture differences between den and non-den habitats

SAND

Group	Sample size	Degrees of freedom	Average per cent sand	Sum of squares
Dens, Camp I	7	6	42.5	295.1
Non-den habitat, Camp I	12	11	47.4	2,806.5
Sums	19	17	4.9	3,101.6

calculated t = 1.58
t(.005)(17) = 2.898
(1) No significant difference between these two sets of data until 80% confidence level.

Group	Sample size	Degrees of freedom	Average per cent sand	Sum of squares
Dens, Camp II	11	10	80.8	230.6
Non-den habitat, Camp II	12	11	47.4	2,806.5
Sums	23	21	33.4	3,037.1

calculated t = 13.31
t(.005)(21) = 2.831
(1) Significant difference between these two sets of data at the 99% confidence level.

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Appendix IV. (Continued)

Group	Sample size	Degrees of freedom	Average per cent sand	Sum of squares
Dens, Camp III	5	4	49.3	1,561.3
Non-den habitat, Camp III	12	11	47.4	2,806.5
Sums	17	15	1.9	4,367.8

calculated t = .4589
t(.005)(15) = 1.400
(1) No significant difference between the two sets of data at the 80% confidence level.

Group	Sample size	Degrees of freedom	Average per cent sand	Sum of squares
Dens, Camp IV	11	10	45.3	414.1
Non-den habitat, Camp IV	12	11	47.4	2,806.5
Sums	23	21	2.1	3,220.6

calculated t = .8139
t(.005)(21) = 2.831
(1) No significant difference between the two sets of data at the 80% confidence level.

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Appendix V. T-test calculations for permafrost difference between den and non-den habitats

Group	Sample size	Degrees of freedom	Average depth in mm	Sum of squares
Dens, Camp I	19	18	236	197,239
Non-den habitat, Camp I	25	24	172	26,232
Sums	44	42	64	223,471

calculated t = 5.818
t(.005)(42) = 2.704
(1) Significant difference between these two sets of data at the 99% confidence level.

Group	Sample size	Degrees of freedom	Average depth in mm	Sum of squares
Dens, Camp II	12	11	875	232,300
Non-den habitat, Camp II	11	10	471	118,626
Sums	23	21	404	350,926

calculated t = 14.96
t(.005)(21) = 2.831
(1) Significant difference between these two sets of data at the 99% confidence level.

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Appendix V. (Continued)

Group	Sample size	Degrees of freedom	Average depth in mm	Sum of squares
Dens, Camp III	5	4	459	37,720
Non-den habitat, Camp III	4	3	350	32,876
Sums	9	7	109	70,596

calculated t = 3.256
t(.005)(7) = 3.499
t(.01)(7) = 2.998
(1) Significant difference between these two sets of data at the 98% confidence level.

Group	Sample size	Degrees of freedom	Average depth in mm	Sum of squares
Dens, Camp IV	12	11	420	218,580
Non-den habitat, Camp IV	11	10	359	20,066
Sums	23	21	61	238,646

calculated t = 3.053
t(.005)(21) = 2.831
(1) Significant difference between these two sets of data at the 99% confidence level.

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Appendix V. (Continued)

Group	Sample size	Degrees of freedom	Average depth in mm	Sum of squares
All dens	48	47	464	685,839
All non-den habitat	51	50	291	197,800
Sums	99	97	173	883,639

calculated t = 18.02
t(.005)(97) = 2.6
(1) Very significant difference between these sets of data.

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Appendix VI. T-test calculations for soil temperature differences between den and non-den habitats

Group	Sample size	Degrees of freedom	Average temperature °F	Sum of squares
All dens	50	49	47.38	1,184.90
All non-den habitat	40	39	43.60	511.66
Sums	90	88	3.78	1,696.56

calculated t = 7.875
t(.005)(88) = 2.660 - 2.626
(1) Significant difference between two sets of data at the 99% confidence level.

Group	Sample size	Degrees of freedom	Average temperature °F	Sum of squares
Dens, Camp I	20	19	44.65	364.90
Non-den habitat, Camp I	10	9	42.00	130.00
Sums	30	28	2.65	494.90

calculated t = 3.3974
t(.005)(28) = 2.763
(1) Significant difference between these two sets of data at the 99% confidence level.

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Appendix VI. (Continued)

Group	Sample size	Degrees of freedom	Average temperature ^{o}F	Sum of squares
Dens, Camp II	13	12	52.62	654.68
Non-den habitat, Camp II	13	12	44.46	125.13
Sums	26	24	8.16	879.81

calculated t = 6.915
t(.005)(24) = 2.797
(1) Significant difference between these data at the 99% confidence level.

Group	Sample size	Degrees of freedom	Average temperature ^{o}F	Sum of squares
Dens, Camp III	5	4	47.60	129.40
Non-den habitat, Camp III	5	4	46.60	139.40
Sums	10	8	1.00	268.80

calculated t = .5405
t(.005)(8) = 3.355
(1) No significant difference between these two sets of data at 80% confidence level.

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Appendix VI. (Continued)

Group	Sample size	Degrees of freedom	Average temperature °F	Sum of squares
Dens, Camp IV	12	11	42.83	35.92
Non-den habitat, Camp IV	12	11	42.75	38.22
Sums	24	22	.08	74.14

calculated t = .2162
t(.005)(22) ≒ 2.819
(1) No significant difference between these data.

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Mr. Tom Brower.	Long-time resident and store owner at Barrow Village, Alaska.
Mr. Dwain Davies.	Field assistant during the summer field-work, June to September, 1962.
Mr. Charlie Edwardson.	Resident of Barrow Village, Alaska.
Dr. Francis H. Fay.	Arctic Health Research Center, Anchorage, Alaska.
Dr. Otto Geist.	The late Dr. Geist provided considerable data and advice on fieldwork in the Barrow area throughout the study, drawing on his own large experience in this area.
Mr. Al Hopson.	Long-time resident and shop owner at Barrow Village, Alaska.
Mr. John Kelly.	Micrometeorologist, University of Washington.
Dr. David Klein.	Leader, Alaska Cooperative Wildlife Research Unit, University of Alaska, College, Alaska.
Dr. David Mullen.	Researcher, University of California, Berkeley, studying brown lemmings at Barrow, Alaska.
Mrs. Sadie Nayakok.	Mrs. Nayakok, long-time resident and deputy magistrate at Barrow Village, provided considerable information on Barrow Village's economy.

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